FAREWELL TO NORTH AMERICAN MEGADRILES

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[1]Systematically important characters of a macerated but clitellate individual seemed important enough to be recorded because they indicated presence of a third endemic species of a zoogeographically important genus.

[2]See, Fender, W.M. 1982. Megadrilogica 4(1-2): 8-11 (this issue).

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A. chenowithensis (McKey-Fender, 1970)
A. collinus (Eisen, 1900)
A. davisi (Mcnab & McKey-Fender, 1952)
A. fenderi (Macnab & McKey-Fender, 1958)
A. garloughi (Smith, 1937)
A. hammondi (McKey-Fender, 1970)
A. hopsonae (McKey-Fender, 1970)
A. hyoides (Macnab & McKey-Fender, 1959)
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A. marmoratus Eisen, 1893
A. oregonensis (Smith, 1936)
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D. bitheca Gates, 1977
D. bivesiculata Murchie, 1961
D. caroliniana Eisen, 1898
D. communis Garman 1888
D. conoyeri Murchie, 1961
D. eiseni Michaelsen, 1894
D. farmvillensis Gates, 1977
D. floridana Smith, 1924
D. fusca Gates, 1943
D. fuscula Gates, 1968
D. gatesi Murchie, 1965
D. glabra Gates, 1967
D. gracilis Gates, 1943
D. invecta Gates, 1955
D. keysei Eisen, 1896
D. koebelei Eisen, 1900
D. komareki Gates, 1977
D. longa Moore, 1905
D. longiseta Murchie, 1963
D. macdowelli Murchie, 1967
D. meansi Gates, 1977
D. michaelseni Eisen, 1899
D. minima Gates, 1977
D. mississippiensis Smith, 1924
D. nova Gates, 1977
D. ornata Gates, 1943
D. pettiboneae Gates, 1977
D. prosenteris Macnab & McKey-Fender, 1955
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D. sandersi Gates, 1955
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D. smithi Macnab & McKey-Fender, 1955
D. sylvicola Gates, 1977
D. texensis Smith, 1924
D. udei Eisen, 1899
D. vaili Gates, 1977
D. varivesiculata, Murchie, 1966
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E. oxkutzcabensis[4] Pickford, 1938 16
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E. hamiger[5] Michaelsen, 1911 16
E. salvadorensis[5] Graff, 1957 16
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E. haffneri Graff, 1957 16
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Ph. hawayana (Rosa, 1891) 47
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[3]Like the generotype, *S. elongatus* also has not yet been recognized in North America from which it must have been taken to England. As a clitellum had been developed, the type presumably was mature. Absence of prostate-like glands and, more significantly, all spermathecae, are abnormalities often allowed when reproduction is parthenogenetic. Absence of spermatozoal iridescence on male funnels and elsewhere could have suggested the male sterility that often, though not always, is associated with parthenogenesis. That method of reproduction has not yet been reported from any sparganophilid.

[4]Supposedly without calciferous glands. Should the species be in the same genus with those having well-developed, calciferous glands?

[5]Supposedly with well-developed, calciferous glands. Should the species be in the same genus with those lacking such glands?

[6]*Plutellus* became "an aggregation of unrelated species", "a massive polyphyletic congeries", with species in Ceylon, India, Burma, Australia, New Zealand, United States, Central America and northern South America. *P. kincaidi* has four pairs of large, bilobed, extramural, calciferous glands in segments xiv-xvii, that forbid transfer to the resurrected *Argilophilus*, as recently defined (Gates, 1977. Megadrilogica 3 (2):55.)

E. saltensis (Beddard, 1892) 66
E. zonalis (Eisen, 1893) 66
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N. panamaensis Eisen, 1900 67
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Ocnerodrilus occidentalis Eisen, 1878 68
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Temanonegia, Gates, 1979 17
T. alba (Gates, 1957) 17
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D. godeffroyi (Eisen, 1900) 68
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D. guatemalae (Eisen, 1900) 68
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D. manni Michaelsen, 1935) 68
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D. nana (Eisen, 1896) 68
D. paessleri Michaelsen, 1901 68
D. papillata (Eisen, 1900) 68
D. picadoi Michaelsen, 1912 68
D. pitahayana Michaelsen, 1912 68
D. reichardti Michaelsen, 1908 68
D. ribaucourti Eisen, 1900 68
D. saliens (Beddard, 1893) 69
D. sporadonephra Cognetti 1905 69
D. townsendi Eisen, 1900 69
D. tristani Cognetti, 1907 69
D. uhleri Michaelsen, 1935 69
D. vereus Cognetti 1905 69
D. vialis Michaelsen, 1913 69
D. viridis (Eisen, 1900) 69
Eutrigaster Cognetti, 1904 16
E. oraedivitis Cognetti, 1904 16
Megascolidea McCoy, 1878 71
M. americanus Smith, 1897 71
M. cascadensis Smith, 1937 71
M. eiseni Smith, 1937 71
M. macelfreshi Smith, 1937 71
M. michaelseni Smith, 1937 71
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Ramiellona Michaelsen, 1935 17
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R. balantina Gates, 1962 16
R. eiseni (Michaelsen, 1911) 16
R. guatemalana Gates, 1962 16
R. irpex (Michaelsen, 1911) 16
R. lasiura (Graff, 1957)
R. mexicana Gates, 1962
R. sauerlandti (Graff, 1957)
R. stadelmanni (Michaelsen, 1935)
R. strigosa (Gates, 1962
R. tecumumami (Michaelsen, 1911)
R. vulcanica (Graff, 1957)
Vide Gates, 1962. Proc. Calif. Acad. Sci. (4), 31(8): 195-218.
Trigaster Benham, 1886 (*sensu* Gates, 1971)[7] 71
T. albida Gates, 1973 71
T. cavernicola Gates, 1962 71
T. intermedia (or *calwoodi*)[8] Michaelsen 1900 71
T. lankesteri Benham, 1886
T. reddelli Gates, 1971
T. rufa Gates, 1962
T. tolteca Eisen, 1900
T. vallesensis Gates, 1971
Vide Gates, 1971. Assoc. Mex. Cave Stud. Bull. 4:4
Eudrilidae[9] 71
Eudrilus Perrier, 1871 72
Eudrilus eugeniae (Kinberg, 1867) 72

Two ghost worms, unembodied in any presently extant material, should not be omitted from any list of American megadriles as each has remained far too long is almost forgotten obscurity:

"*Criodrilus* or a related genus", Eisen, 1892. Zoe 2: 232. ("caught in the Mississippi River in 1891")

"*Drilocrius* sp.", Wurtz and Roback, 1955. The invertebrate Fauna of some Gulf Coast Rivers. Proc. Acad. Nat. Sci. Phila. 187: 184. The habitat seemingly suggests a possibility that a sparganophilid or even *Lutodrilus multivesiculatus* might have been involved. However the author of the latter taxon did not seem to be at all interested in considering such a possibility.

INTRODUCTION

Circumstances, over which the author had no control, finally ended his sixty-year study of megadrile oligochaetes. Including, one species which, instead of being used as fishbait, actually is specialized to feed on a certain kind of fish (Gates, 1971).

This valedictory is a melange of previously unpublished records, observations, opinions, and still unanswered questions. Mostly on the earthworms of North America (which includes Mexico, Central America and the West Indies).

The history of Oligochaetology, mainly concerned with the names of Europeans such as Beddard, Benham, Cernosvitov, Cognetti, Eisen, Pickford, Rosa, Stephenson, Ude and Vejdovsky, provides no reason for American pride. Table 1 shows that an important percentage of native megadrile species in the mainland states of the U.S. were first described and named by foreigners: Three Englishmen, Benham, Stephenon, and a Wesleyan clergyman whose hobby was earthworms, the Reverend Hilderic Friend. Two Germans, Michaelsen and Ude. One Swede, Eisen and a Canadian, Reynolds. Would any Yankee have been able to function acceptably as a minister, in this country, if his hobby was, not megadriles, not even oligochaetes, but actually earthworms(!)? Why have Americans whose dissertations were on earthworm research, acquired no interest in further study of such interesting animals that pose so many unanswered and challenging questions? Were too many prospective zoologists exposed to a high school course in which they learned "all about" THE EARTHWORM and may even have looked briefly at the pinned-open corpse of one of them?

[7]The "generic precis" is offered only as a temporary first approximation, in Gates, 1971, Assoc. Mexican Cave Stud. Bull. 4: 3, with a key to seven of the eight species now known.

[8]Michaelsen's three subspecies of *T. lankesteri, calwoodi, intermedia,* and *typica* are not subspecies as that taxon now is understood. At least two endemic *trigasters,* if not also a third, probably were present on St. Thomas, in the previous century. Is it too late now to secure them again? None of that genus are known to have been transported. What is the significance of endemic megadriles on that island?

[9]This deviation from the usual alphabetic order above, indicates the authors feelings about the relationship of this family to other megascolecoid families.

Table 1. Foreign authors and first describers of American earthworm species.

Author	*Argilophilus*	*Bimastos*	*Diplocardia*	*Eisenoides*	*Komarekiona*	*Lutodrilus*	*(Megascolides)*[1]	*Pontodrilus*[2]	*Sparganophilus*[3]	*Totals*
Benham	1								1	2
Eisen	3	2	4						1	10
Friend									1	1
Michaelsen	1	1	1	2						5
Reynolds									8	8
Stephenson		1	2							4
Ude		1	2							3
Known number of species	19	9	38	2	1	1	6	2	13	30

[1]The six Pacific coastal endemics now in the named Australian genus, do not belong there and a new genus is needed.

[2]Omitting *Pontodrilus bermudensis* Beddard, 1891, not previously suspected of being American? "Nothing is known as to the original home of the species (one guess, in region of Australia-New Zealand) or as to how species have spread around the world" (Gates, 1972a: 47).

[3]Three species apparently are unrepresented by any type material. The types of eight species are in foreign museums!

All too often "THE" earthworm (without any appositional phrase or clause) has been mentioned in speech and in print. Perhaps as one result, is the recent publication in American journals of articles reporting research on *Lumbricus terrestris,* when *Aporrectodea tuberculata, Eisenia foetida* or some other megadrile was involved. (For several instances *vide* Gates, 1978a:87. Also, the paragraph on Vermisol in Gates, 1979:166.)

German zoologists, in the days when Frank Smith was the only native American with an interest in megadriles, arranged for their own countrymen visiting here, to obtain and get to Germany for study, preserved earthworms. Type specimens of 22 native American species are in European museums or were lost. Of the thirteen species of the American genus *Spargonophilus,* types of three species are in the British Museum, of five species are in a Canadian Museum. Types of four species were lost and the location of one recently-named species is unrecorded.

How many American zoologists are aware of the diversity of earthworm organization in their own country? Thirteen megadrile families now are known to be represented in North American faunas. Just two of them, the Almidae and the Moniligastridae, have not yet been reported from the mainland states. Thirty-two genera of those thirteen families are now present in mainland states of the U.S. Seven, *Argilophilus, Bimastos, Diplocardia, Eisenoides, Komarekiona, Lutodrilus* and *Sparganophilus* are definitely endemic here. Only three species are not so limited geographically, *Bimastos parvus,* which probably taken from the U.S. to Britain and thence to every part of the world to which Britains have gone. *Sparganophilus elongatus* and *tamesis,* almost certainly taken unwittingly to England, from this hemisphere where their original distribution still is unknown.

Canada of course has no native earthworms, any such having been exterminated during the last ice age. *Sparganophilus eiseni* may have migrated into southern Ontario province, after recession of the ice, probably very recently. Otherwise all megadriles now present in Canada were unwittingly introduced since 1500 A.D., or deliberately for several species since World War II.

The seven endemic genera of the mainland states are known to contain at least 93 species. The "at least" is emphasized as the author has seen undescribed species in at least three of the genera that could not be adequately characterized and so still need to be described and named. Additionally, two, new, generic names are needed for known endemics of the Pacific coastal region. One for *Plutellus kincaidi* Altman, 1956, excluded by its extramural calciferous glands from *Argilophilus* as now defined (Gates, 1977: 55). The acanthodrilid *Plutellus* is a congeries of species native to Ceylon, India, Burma, New Caledonia, Tasmania, Australia, New Zealand, etc. Another name is needed for the six octochaetid species now in the Australian genus *Megascolides* McCoy, 1878.

Each of two additional genera, *Haplotaxis* and *Pontodrilus,* has one species apparently or supposedly endemic in the mainland states, but with other formae, morphs, species or varieties outside of this hemisphere. Most of the taxa involved need much further study, especially more precise and detailed anatomical characterization. Also unknown and of special interest for each American species, is where it originated and how it got to its present distribution.

Each species of 17 further megadrile genera that is now present in the mainland states, is here because it was unintentionally introduced, *i.e.,* it did not get here by its own efforts. But how did they all arrive?

When the author first came into contact, in 1920, with oligochaete literature such as Beddard's monograph (1895), he was impressed by the fact that any earthworm could be characterized as endemic (native) or exotic (foreign, peregrine, widely wandering). Somehow, the author acquired a suspicion that endemics alone were considered to be really interesting. But, the seemingly less-interesting wanderers were here, there, at almost any place, even beyond oceans supposedly impossible for earthworms to cross because of fatal susceptibility to the salts in the water. (*P. burmudensis* is reported herein-p. 34 from mud saturated with ocean water.) Where the exotics had originated seemingly could be characterized only by general terms such as European or American. Earthworms had been exterminated, during the most recent glaciation, in northern Europe, Canada and some eastern adjacent parts of the U.S. The decimated areas of the U.S. (and also of Europe?) had not remained wormless as species from the unglaciated portions of those continents supposedly had moved northward, perhaps as soon as the absence of ice allowed. But, in glaciated Michigan and Ohio immigrant American endemics were far fewer and much less widely distributed than the European exotics. How then had the widely distributed European peregrines gotten to the United States? And elsewhere in so many parts of the whole world? Those, as well as many other questions were not satisfactorily answerable by one who always had felt a special interest in the exotics.

Inability to return to Burma after World War II provided an opportunity to hunt for facts. Involved were a search of non-scientific literature, perusal of histories of horticulture, especially in the U.S.. Collection and identification of greenhouse earthworms from as many states as possible. Years ago, oligochaetologists occasionally had reported obtaining at Kew, Paris, and Hamburg, exotic earthworms in shipments of live plants from abroad. Such data may never have been continuously collected over any period of time, at least in the United States. Early in 1949, the right contact was made and Dr. C. W. F. Muesebeck was interested in the project. He (assisted by others?) was able to arrange for preservation and forwarding to the author of oligochaetes encountered during a search for quarantineable plant pests at various (though probably not all) ports of entry for this country. Thousants of oligochaetes were obtained during the last thirty-two years and, insofar as was possible, identified. Earthworms are not officially regarded as pests, their importation is not prohibited and this author suspects that the specimens

intercepted as a result of Dr. Muesebeck's arrangements may have been but a portion of the total that might have been obtained if all ports of entry had always been involved. Or, if importation of earthworms were prohibited.

Although some of the desired data was not obtained, much information of interest was secured. Identification of worms with plants from Honduras and Nicaragua enabled the first records of any megadrile species for each of those Central American countries. First records of certain exotic earthworm species for other countries, including some in Europe, became available. Each European lumbricid now domiciled in the U.S. (except *Ap. limicola, longa, Murchieona muldali* and *Satchellius mammale*) was identified and reported as having been intercepted during the last quarter century. Numerous instances of importation of live trees (pear, apple, *etc.*) to English and Dutch colonies well before the revolution, as well as transfers of many live plants from the southern colonies to England, were found. Intercepted megadriles from Mexico enabled a much better characterization (Gates, 1977f :480) as well as rescue of *Phoenicodrilus* from a synonymy in which it long had been buried. The greenhouse industry (along with private conservatories) was found to be capable of effective function as a dispersal agent, even before 1776. A wide-ranging literature search[10] showed time and again that earthworms were lacking in glaciated areas of Canada and various adjacent states until after arrival of European settlers.

Only one of the above-named, endemic genera is known to have species (presumably endemic) outside of the U.S. The five, all from Mexico are: *D. alba mexicana* Gates, 1955, known only from a damaged specimen intercepted at Brownville, Texas, in 1950. *D. caroliniana* Eisen, 1899, now recorded from twelve states in an area extending from Texas through Tennessee into Maryland. Nine specimens from Chihuahua were intercepted at El Paso in 1962. Is the species as widely distributed in Mexico, as to the north? No evidence has yet been found to indicate human transport of the species in the opposite direction. *D. invecta* Gates, 1955, first described from nine types intercepted at Hidalgo, Texas, in 1954, subsequently recorded (Gates, 1977) from Texas (1 or 2 sites?). Could the species be primarily Mexican? *D. keyesi* (Eisen, 1896) of Baja California, known only from the description of the holotype which, after being sectioned, was lost. *D. koebelei* Eisen, 1900 of Morelos, Mexico, known only from the types which were lost. *Sparganophilus benhami* Eisen, 1896, from Tepic, Mexico, *S. b. guatemalensis,* from Guatemala City, though recognized by Michaelsen in 1900 and 1917, were placed in the synonymy of *S. eiseni* by Hague (1923) where they have been ever since. Reconsideration is advised.

Except as just noted above, all North American, endemic megadriles south of the Rio Grande and Florida are in genera not similarly represented to the north. They are as follows:

Andiodrilus Michaelsen, 1900, Glossoscolecidae. Two species had been recorded from Costa Rica when megadriles of the region were last reviewed (Gates, 1942a).

Balanteodrilus Pickford, 1939. Acanthodrilidae. The single species still is known (Gates, 1977e) only from three caves in Yucatan, Mexico.

Diachaeta Benham, 1886, Glossoscolecidae. Two species; *D. barbadensis* (Beddard, 1893) supposedly from Barbados and *D. thomasi* Benham, 1886 of Jamaica, St. Thomas and Trinidad.

Dichogaster Beddard, 1888, Octochaetidae. An Afro-American, classical congeries of about 200 species. Most of which, including the African generotype, *D. damonis* Beddard, 1888, are inadequately characterized. Burmese material (Gates 1942b and 1958b), probably of the most widely distributed species, enabled more adequate characterization of a *bolaui* species group (Gates, 1972a; 277). At least three species of that group are present in North America. The author's checklist (1942a; 94-96) named 27 North American species of which three are of that *bolaui* group. Nineteen of the remaining 24 species were known only from the original description. The 24 probable endemics are of Mexico, Central America and the West Indies. An African origin of the genus has been suggested but without really good evidence.

Drilocrius Michaelsen, 1918, Almidae. One species, in Costa Rica.

Eodrilus Michaelsen, 1907, Acanthodrilidae. Another classical congeries. Indeed, the author pointed out (Gates, 1967; 68) that Mexican species could go equally well into *Eodrilus* as defined by Michaelsen (1907) or by Pickford (1937) or into *Acanthodrilus* as defined by Stephenson (1930). Each of those two genera has species presumably endemic in Australia, New Zealand, Central America and Mexico, South Africa and Madagascar. The previous checklist (Gates, 1942a; 88) mentioned nine American species, each one of which was inadequately characterized and known only from the types. Subsequently, five species were added: *E. haffneri, salvadorensis* and *zilchi* Graff, 1957, *mexicanus* Gates, 1967 and *albidus* Gates, 1973. Three species, *E. eiseni, irpex* and *tecum-umami,* with meroic nephridial systems had to be transferred to the Octochaetidae where they now are in a genus, *Ramiellona,* that is somewhat less heterogeneous morphologically. Five species at least, *crystallifer* (Eisen, 1900), *divergens* (Cognetti, 1905), *hamiger* Michaelsen, 1911, *salvadorensis* Graff, 1957, and *tamajusi* (Eisen 1896) appear to have well-devoped calciferous glands and of course should be placed in a different genus from those species lacking such glands. Whether any calciferous tissue is present, is unknown, in two species, *E. haffneri* and *zilchi,* Graff, 1957.

Estherella Gates, 1970, Glossoscolecidae. Only three species are known, at 2200-2500 feet on El Yunque Mt., and 1800 feet in the Caribbean National Forest, Puerto Rico.

Eutrigaster Cognetti, 1904, Octochaetidae. A genus of doubtful status, with only one species, in Costa Rica.

Ocnerodrilus Eisen 1878, Ocnerodrilidae. Another Afro-American congeries with endemics in tropical portions of both continents. The author, attempting a revision with hopelessly inadequate numbers of specimens, found (Gates, 1973) that: *O. ocnerodrilus* Eisen, 1878, the type of its genus as well as of the subfamily and family, with a type locality in California to which it had been introduced (from where?) was not the name of an interbreeding population. On the contrary, it was merely an aggregate of athecal, parthenogenetic morphs (without spermathecae (the organs in which foreign sperm received during copulation are stored). Descriptions of *O. beddardi, guatemalae, hendriei, sonorae* Eisen, 1893, as well as *comondui* and *mexicanus* Eisen, 1900, showing various other stages in the degradation of the genitalia (of a possible common ancestor) were placed in the synonymy of the generotype. As also was *O. calwoodi* Michaelsen, 1898, seemingly with the least change from supposedly normal ocnerodrile genitalia and so believed to be closest to an anticipated amphimictic population. Five of Eisen's Guatemala species[11] were not synonymized because of bits of more or less weakly contra-indicating evidence in the original descriptions from which the taxa (typeless) alone are known. The lack of further synonymization enabled some hope that an anticipated amphimictic population

[10]Old archives, if they can be found, may be able to provide interesting data. One promising source, Spanish archives. A former student, after doing some graduate work in Spain kindly informed the author, several years ago, that records of the live plants taken by Columbus, Cortez, etc., on their later voyages to this hemisphere, still were available in some government office.

[11]*O. agricola, contractus, limicola* and *rosae* Eisen, 1893, *tuberculatus* Eisen 1900.

might still be extant, if not in Guatemala, perhaps elsewhere in Central America, in much of which megadriles certainly never have been collected.

Onychochaeta Beddard 1891, Glossoscolecidae. Two little-known species in Panama, Cuba, Haiti.

Phoenicodrilus Eisen, 1895, Ocnerodrilidae. Nineteen intercepted Mexican specimens and two collected by Loveridge on the island of Saint Helena enabled retrieving the genus (Gates, 1977f: 481) from the synonymy of *Ocnerodrilus* where it had been buried and long forgotten. Calciferous glands of three African species in the subgenus *Ilyogenia* of *Ocnerodrilus* fortunately had been so described as to allow transfer to the reinstated genus. The species, *P. denti* (Stephenson, 1930), *granviki* (Michaelsen, 1921), and *pretorianus* (Stephenson, 1925) were known respectively from two East African specimens, several much macerated Nairobi individuals and eight South African worms. One, at least of the African taxa, like the American generotype, known from 5 Mexican states, has parthenogenetic morphs. Reduction of the North American lumbricid genus, *Eisenoides*, to two species and the elimination of amphimixis in the American *Bimastos*, has been thought to have resulted from the recent glaciation in the northern hemisphere. But how is the parthenogenesis of African and Mexican species to be explained? Presence of the generotype of *Phoenicodrilus* on Saint Helena, certainly makes it easier to suggest that the African taxa may be of American origin.

Pontoscolex Schmarda, 1861, Glossoscolecidae. The only endemics of this genus are little known species from Central America (Guatemala) and a northernmost area of South America.

Ramiellona Michaelsen, 1935, Octochaetidae. Fifteen Mexican and Central American autochthones, three of which had been in the Acanthodrilid congeries, *Eodrilus*, another three of which had been in the subgenus *Graceevelynia* of the octochaetid congeries, *Howascolex*. Seven of the species are from a small portion of Guatemala, the others from Hondurus (1), Mexico (4), Salvador (3). One species *R. americana* (Gates, 1957) is known only from the original description of a posterior amputee intercepted from Guatemalan cargo on a plane arriving at San Pedro in 1955. Unfortunately, because of the very poor condition, this author's species could not be characterized as adequately was desired. Each taxon of the entire genus needs further study, and from better material.

Temanonegia Gates, 1979, Ocnerodrilidae. Four species (Gates, 1957) *alba, dominicana, magna* and *montana* reluctantly placed in the classical *Nematogenia* Eisen, 1900, until additional material could be obtained. The desired specimens never having become available, a new genus was named for them, largely to eliminate the evidence supposedly for an African origin and to call attention to possibly unnoticed support for an American origin of the family.

Thamnodriloides Gates, 1968, Glossoscolecidae. One species, *T. yunkeri* Gates, 1968, known only from the description of a posterior amputee, secured at Cerro Pirre, Darien, Panama.

Trigaster Benham, 1886, Octochaetidae. Eight species (key to seven in Gates, 1971a), in Mexico, Cuba, Puerto Rico, St. Thomas.

Zapotecia Eisen, 1900, Acanthodrilidae (?). Two species (without types), known only from the original description of a probably sectioned holotype or immature specimens, Mexico and Haiti.

SYSTEMATICS
ORDER MONILIGASTRIDA

A definition of the Moniligastridae in "Burmese Earthworms" (Gates, 1972a: 238) contained 46 italicized words, in contrast to most other, therein definitions which had no single phrase so emphasized. The accentuated taxonomic characters, somatic as well as genital, are uniquely limited to the family being defined. One other character, considered below, at the time of writing, probably could have been italicized but, for reasons now forgotten, was not so emphasized. So much uniqueness, certainly most unusual in megadriles, recently has been recognized as warranting recognition of a distinct oligochaete order, with only one family, the Moniligastridae.

All non-moniligastrid megadriles (if not all oligochaetes) primitively must have discharged matureing gametes of both sexes into unspecialized, segmental, coelomic cavities. Further development of the gametes, in most megadriles, involves passage of male cells into seminal vesicles and of female cells into ovisacs. Eventually, from those organs the gametes return to the same body cavity as before. There, sex cells can be lost on each occasion: To protozoa, nematodes and hexapod parasites. Perhaps even to the species, own, coelomic phagocytes. Perhaps also by wandering into neighbouring metameres from which there is no natural way of escape for usual reproductive functioning. Such losses can be avoided by development of closed systems in which gametes are confined until they are passed out of the body, by the proper gonoducts. One system for the sperm and another for the ova. Many megadriles have such a closed system but only for male cells. It includes testis sacs, containing closed off, small portions of a gonad-segment, coelomic cavity, containing one or two testes and their gonoducal funnels, always appropriately associated with one or two seminal vesicles. Fewer megadriles evolved a second closed system for the female gametes such as that of the *sedgewicki* pheretimoid group. It also closes off from the remainder of the gonad-segment, coelomic cavity, a small portion containing a single ovary and one oviducal funnel. No ovisacs seemingly are needed.

Every moniligastrid, like the individuals of the *sedgewicki* complex, has two closed systems. The female system likewise involves closing off in a small portion of the gonad-segment, coelomic cavity, one ovary (or two ovaries) and associated oviducal funnel or funnels. The moniligastrid male system is unique, as the male gametes never get into a coelomic cavity or even any small portion of one. The so-called testis sacs of moniligastrids are not sacs at all but merely septal thickenings in which sperm, male funnels and gonoducts develop. Seminal vesicles as well as ovisacs always are absent in moniligatrids.

The moniligastrid prostomium, unlike that of most other megadriles, though called prolobous (Gates, 1972: 239) just from force of habit, is not an anterior protuberance of the peristomium. Completely separated from that segment, the fleshy lobe is on the roof of the buccal cavity very slightly behind the level of intersegmental burrow 1/2. Although it's use had not been studied *in vivo*, it obviously can be withdrawn into the anterior end so completely as to be invisible from the exterior. Or, it can be protruded so that it long had been characterized as zygolobous or even as prolobous. Its origin has been attributed to a deepening of the transverse furrow demarcating a prolobous prostomium from the peristomium and its subsequent continuation posteriorly to the level of 1/2. BUT, did the moniligastrid organ develop *in situ*, independently of any connection with the peristomium, as a totally new structure? Hopefully, its origin can be determined definitely from an examination of its embryonic development.

MONILIGASTRIDAE

Much remains to be learned about most of this family of five genera. Even in Burma, where earthworms were collected as exhaustively and as widely as finance permitted during a period between World Wars I and II. Species of two of the three genera in Burma, for example, still are known only from 22, 2, 4, 1 and 2 individuals and the seven types of three of those species are all immature. Yet, one night a year, late in October or early in

November, well after the last storm of the rainy season, one at least of those five species, surfaces by the hundreds or thousands, only to be dried out in the next days heat. During a period of more than twenty years, the author never found any evidence in support of a formerly supposed predilection for saturated environments. No species of four genera, *Desmogaster, Eupolygaster, Hastirogaster* and *Moniligaster,* ever has been collected outside its area of endemicity. That along with the difficulties encountered in securing material of various species in places where they are known to have been present, seem to show, at least an aversion to human activity, if not also a definite inability to survive any such influences.

The family range extends from south India through Burma, the Malay Peninsula, Thailand, Indo-China and China to Manchuria, Far Eastern Siberia, Korea and Japan down to Borneo and Sumatra. Such a range is large and may be exceeded in size only by that of the Lumbricidae.

Drawida Michaelsen, 1900

Only for Burma and for *Drawida* alone, is our knowledge sufficiently advanced to allow recognition of geographical subspecies. Examination by the author (Gates, 1937a) of a type showed that *Moniligaster straeleni* Michaelsen, 1930, from Palembang, Sumatra, really belonged to *Drawida longatria longatria* Gates, 1925, of the deltas region in southern Burma. The same subspecies has been carried (Gates, 1972a: 252) very probably by man, to Bhamo and Myitkyina districts in the far north of Burma. That transportation is easily explained as Burmans, and others, long have been known to carry live, ornamental plants from one part of the country to another. No explanation has been found for the oversea transport to Palembang, Sumatra.

A second, transported *Drawida, D. bahamensis,* is further considered below. A third species, *D. barwelli* (Beddard, 1866), based on twenty immature specimens from Manila, unfortunately was designated the generotype of *Drawida* by Michaelsen. Unfortunately, because: 1) Original and subsequent accounts of the species contained so many mistakes, even including miscorrections of previous errors. 2) The type lot may have included a second species, as Beddard himself, at least once suggested. 3) Of the twenty types only two tail ends remain. The present author, after studying the situation concluded, it may well be forever impossible to determine what *D. barwelli really was. Indian material referred to the species by Stephenson and by* Iyer, always was distinguished from the Philippine types as variety *impertusa.* The latter now (Gates, 1965b) is recognized as a good Indian species that also has been found outside of India only at four sites in the Philippines.

Other moniligastrid transports are: *Drawida nepalensis* Michaelsen, 1910, with a type locality in Nepal, transported to the Andaman Islands and Buitenzorg, Java, as well, probably, as some what in India and Burma. *D. japonica* (Michaelsen, 1892) probably originally from the Eastern Himalayas and/or Yunnan as well as Szechuan, with a type locality in Japan! *D. parva* (Bourne, 1894) a dubious taxon that cannot be defined adequately or recognized, of India but recorded from Aru Island.

The natural range of the genus is almost identical with that of the family. The writer suspects many species still are unknown. The range is greater than that of the "all conquering" *Pheretima,* and is exceeded, if at all, only by that of the family Lumbricidae.

Drawida bahamensis (Beddard, 1892)

North American records

1892 *Moniligaster bahamensis* Beddard. Proc. Zool. Soc. London, 1892, p. 690. (Types, 2, now missing, supposedly imported to Kew from the Bahamas.)

1954 *Drawida bahamensis,* Gates. Bull. Mus. Comp. Zool. Harvard, 111 (6): 241. (Cidras, at 1200 feet, Puerto Rico, two specimens.)

1965 *Drawida bahamensis,* Gates. Ann. Mag. Nat. Hist. (13), 8: 85. (Calayan Island, Philippines, 33 specimens. One adolescent, from earth with roots of an avocado plant coming from Nicaragua, was intercepted at Brownsville, Texas, in 1957. Previously no species of earthworm had been recorded from Nicaragua. Description, defining precis.)

Material examined: Interception. **TONGA.** From 15 pounds of earth in baggage on plane arriving at Honolulu, 27 Aug 62, 2-0-0.

Reproduction

In absence of any definitive evidence to the contrary, presumably is amphimictic. (But see Gates, 1972a: 238.)

Distribution

The original source from which this species was taken, presumably by man, is unknown. The author long has suspected the species may have originated in China but can offer no supporting evidence. The Philippines, on the contrary, are within the family range and two other species of small size, little if any larger than *bahamensis* actually were recorded from the islands. One of them, the generotype of *Drawida,* with Manila as its type locality, probably is forever unrecognizable. The second species, *D. impertusa,* until this author (1965: 87) recorded it from the Philippines, Calayan, had been regarded as an Indian endemic! Assuming that the single Philippine record, Calayan is located in an area from which *D. bahamensis* was first taken away by man, how did it get from there to: Bahamas, Flores, Nicaragua, San Juan Island and Tonga?

ORDER HAPLOTAXIDA
SUBORDER HAPLOTAXINA
HAPLOTAXIDAE

Haplotaxids, supposedly inhabiting wells, spring-fed pools, very deep lakes especially in mountains, subterranean waters, etc., often have been characterized as aquatic. One author called them well-worms. Actually, the worms probably often live in some kind of cryptic soil environment that ordinarily is saturated but from which occasional individuals wander away or even are driven out, just as other megadriles ordinarily living in unsaturated soil sometimes are driven out to wander aimlessly at the surface during an occasional rainstorm. French zoologists (*vide* Gates, 1971b: 209) believed that the most widely recorded species really is terrestrial and breeds only in earth. This may be one instance in which the word "limicolous" (mud-dwelling) may communicate information more precisely than "aquatic" does.

The suborder and family and represented in North America by two species of the genus *Haplotaxis:* 1) *H. gordioides* (Hartmann, 1821), known in many of its areas only from immature individuals, may be another "classical congeries" masquerading as a species. The taxon has been recorded from a dozen European countries, Central Asia, Siberia, Japan and half a dozen lower mainland states of the U.S.A.[12] No record of human transportation that might be of interest in such a distribution has been found. 2) *H. ichthyophagous* Gates, 1971, known only from the original description of juveniles from Humboldt County, California. Because of its possible economic importance to the salmon fishery, one might have been justified in anticipating further investigation of the

[12]Gates, 1971. On a new species of California earthworm, *Haplotaxis ichthyophagous* (Oligochaeta, Annelida). Proc. Biol. Soc. Washington 84 (25): 203-212.

species. Nevertheless, each effort to obtain additional and especially of mature material, or to awaken interest in study of such an interesting worm, was futile. However, it is noteworthy that available material, though juvenile, may have exceeded in number of individuals the number studied of any other Haplotaxid species, if not also the total studied of all other Haplotaxids.

The range of the family, which also includes Australia, New Zealand, South America, Africa, as well as various oceanic islands "seems to comprise most of the habitable world" and certainly is "much greater than of any other megadrile family" (Gates, 1972a: 58-60). That range, insofar as could be determined, was obtained without any of the human assistance, some few members of most other megadrile families have had. Classical oligochaetologists believed the Haplotaxidae gave rise to all of the other earthworm (megadrile) families. Does any other oligochaete family have a more likely claim to an origin on the ancient supercontinent, Pangaea?

SUBORDER LUMBRICINA
SUPERFAMILY GLOSSOSCOLECOIDEA

This superfamily is distinguished by its ovaries which primarily are band or ribbon-shaped and without egg strings.

Of the four families now included (Sims, 1980: 110), only one is represented in the United States, and almost certainly by exotic species only.

GLOSSOSCOLECIDAE

Cephalization, in some glossoscolecids, has involved certain, somatic modifications that are lacking in most other megadrile families. Such "swallowing of its own anterior end", as the evolutionary changes were picturesquely characterized, poses problems about organ locations along the anteroposterior axis that require exact solution because of their taxonomic importance. *Pontoscolex corethrurus* still shows early stages in that swallowing process.

The definition of this family in a recent monograph (Brinkhurst and Jamieson, 1971: 723) contains the following qualifying words; or (15 times), rarely (6 times), usually (4 times), sometimes (thrice), often, frequently, and very rarely (twice each), occasionally and exceptionally (once each). One single statement unqualified by any of those just mentioned words, included this hedgeing parenthesis "(always?)." The character involved is, location of the male gonoducts within body wall musculature, a condition said (*Idem*, p. 62) to be not only constant in, but also diagnostic of, the family. Male gonoducts, according to Righi (*in litt.*, 1973), are superficial (rather than embedded in the parietal musculature) in some species of the following seven, glossoscolecid genera; *Alexidrilus, Andioscolex, Fimoscolex, Glossoscolex, Goiascolex, Martiodrilus, Pontoscolex.* The supposedly definitive character is neither constant in nor diagnostic of, even the tribe Glossoscolecini. Elsewhere, imbedded sperm ducts were recorded for the North American, acanthodrilid, *Diplocardia communis* Garman, so long ago as 1888. Sperm ducts also are embedded within the parietal musculature, in some species only, of each of the four moniligastrid genera. In that oriental family, the character now seems to be definitive only at species level.

Surely, at family level, the contained genera should be expected to have at least one character in common beyond that of being earthworms!

As a purely American family, a definition without qualification or exception was possible (Gates, 1972a: 52) more than 15 years ago (but now see Glossoscolecidae sp. III). As so defined, the family is neither limicolous nor aquatic.

As in the Eudrilidae, only one species of this family has obtained wide extracontinental distribution.

Pontoscolex Schmarda, 1861

This genus, containing the only glossoscolecid species domiciled outside of the American hemisphere, otherwise is poorly known. It has been thought to be most closely related to the following south American genera; *Meroscolex* Cernosvitov, 1934, *Onychochaeta* Beddard, 1891, *Opisthodrilus* Rosa, 1895, and *Rhinodrilus* Perrier, 1872. Each of them does have, in segments vii-ix, paired calciferous glands, supposedly with dichotomously branched longitudinal canals. Otherwise those genera were mainly distinguished from each other by the very genital characters now known to be most liable to rapid evolutionary modification.

Aside from the taxon next to be considered, only three species have been placed in this genus; *lilljeborgi* Eisen, 1896, *hingstoni* Stephenson, 1931 and *vandersleeni* Michaelsen, 1933. Each is known only from the original account, which lacks data now needed to adequately define a species. Especially with reference to formerly derogated somatic systems.

The region in which the autochthones were secured includes Guatemala, Panama (?), Guyana and Surinam.

Pontoscolex corethrurus (Müller, 1856)

North American records

1861 *Pontoscolex arenicola,* Schmarda. Neue wirbellose Thiere, Leipzig, 1(2): 11. (Jamaica)

1892 *Pontoscolex arenicola,* Beddard. Ann. Mag. Nat. Hist. (6), 9: 126. (Jamaica)

1896 *Pontoscolex corethrurus var. mexicanus,* Eisen. Festskrift Lilljeborg, Upsala, p. 8. (Tepic, Mexico at 4,000 feet.)

1899 *Urochaeta* sp., Harrington. J. Morph. 15 (Sup.): 155. (Comment on blood circulation in juveniles. Source of specimens not indicated.)

1900 *Pontoscolex corethrurus,* Cognetti. Boll. Mus. Zool. Torino 15: 10. (Subsp. *mexicanus* not justified.) *P. c. mexicanus,* Eisen. Proc. California Acad. Sci. (3), 2: 87. (Mexico, Baja California south from Todos Santos. On the mainland, Mazatlan, San Blas. In Guatemala, Hondurus and Salvador, "the species extends from the Atlantic to the Pacific" in the lowlands.)

1904 *Pontoscolex corethrurus,* Cognetti. Boll. Mus. Zool. Torino 19: 462. (Costa Rica.)

1905 *Pontoscolex corethrurus,* Cognetti. Boll. Mus. Zool. Torino 20: 495. (Panama.)

1908 *Pontoscolex corethrurus,* Michaelsen. Zool. Jahrb. Syst. Sup. 11: 29. (Haiti, Jamaica, St. Thomas, San Domingo.)

1927 *Pontoscolex corethrurus,* Gates. Biol. Bull. 53: 352. (Experiment on anterior regeneration abandoned because of great slowness of the process.)

1936 *Pontoscolex "coretrurus"* (part), Cernosvitov. Vest. Cesk. Zool. Spol. Praze, 3: 3. (Excluding specimens with paired setae posteriorly. Baja California.)

1942 *Pontoscolex corethrurus,* Cernosvitov. Proc. Zool. Soc. London, 1942, p. (Bonaco, West Swan Island, Hondurus.) Gates, Amer. Midland Nat. 27 (1): 99. (In check list of North American earthworms with keys to species.)

1943 *Pontoscolex corethrurus,* Gates. Ohio J. Sci. 43(2): 92. (Detailed description of Philippine worms.)

1954 *Pontoscolex corethrurus,* Gates. Bull. Mus. Comp. Zool. Harvard, 111 (6): 219. (First mainland U.S. records, greenhouses in Chatham, N.J., and Pana, Illinois. New Jersey worms supposedly had been taken into the greenhouses during ten years along with soil from a nearby bank. Also Haiti, Puerto Rico, St. Thomas.)

1957 *Pontoscolex corethrurus,* Graff. Senckenbergiana (Biol.) 38: 141. (El Salvador.)

1962 *Pontoscolex corethrurus,* Gates. Proc. Biol. Soc. Washington 75: 140-143. (Evidence for parthenogenetic reproduction in the species summarized.) Proc. California Acad. Sci. (4), 31: 219. (Eisen's Guatemala specimens examined. Reproduction is parthenogenetic because of male sterility.)

1972 *Pontoscolex corethrurus,* Gates. Burmese Earthworms, p. 54. (A proboscis as well as a prostomium is lacking.) Righi, Stud. Neotropic. Fauna 7: 225. (Costa Rica.)

1973 *Pontoscolex corethrurus,* Gates. Bull. Tall Timbers Res. Stn. No. 14: 1-12. (Florida, Brevard, Dade, Lucie, Marion, Orange, Volusia Counties. Puerto Rico, Hawaii, 16 sites on Oahu. St. Helena Island, 10 sites. Interceptions: from Mexico (7), elsewhere (10). Sperm had been matured profusely by five St. Helena worms, two of which also had received sperm from another worm in a copulatory act, p. 8.)

1963 *Pontoscolex corethrurus,* Gates. Proc. Biol. Soc. Washington 76: 15. (Greenhouse worms. At Chatham, New Jersey, "the worms were brought inside from a bank of soil (behind the greenhouses) where they had been living at least from 1937 to 1947". As a result of their presence, soil in the plant benches "became so hard that one can scarcely shove his finger down into it". Infestation by worms in the plant benches "advanced at a rate of 50 linear feet a year". The species supposedly also had been found in a golf green of a New Jersey Country Club. Information above was supplied by a technical director of an insecticide company. Confirmation of presence in any golf green has not been obtained.GEG)

Material examined: **FLORIDA.** COLLIER CO. Collier, Seminole State Park, 2 Jul 1968, 7-0-0 (TF-401). Marco, 2 Jul 68, 53-0-0 (TF-400) W. W. Baker & P. Jinright. Jerume, 15 Mar 73, 28-1-1 (KO-218) B & E. V. Komarek, Sr. DADE CO. Florida City; 13 Nov 67, 0-1-7 (TF-657B) E. V. Komarek, Sr., 3 Jul 68, 24-0-0 (TF-407) W. W. Baker & P. Jinright. North Homestead, 3 Jul 68, 4-0-0 (TF-405) W. W. Baker & P. Jinright. West Miami, 14 Aug 74, 0-0-1 + a head end (KO-225), 0-1-29 (KO-232), E. V. Komarek, Sr. DE SOTO CO. Arcadia, 2 Jul 68, 53-0-0 (TF-398), to the west, 0-1-10 (TF-397b), W. W. Baker & P. Jinright. GLADES CO. South Lakeport, 4 Jul 68, -20-0 (TF-412) W. W. Baker & P. Jinright. La Belle, 15 Mar 73, State Road 26, 5-3-18 (KO-217) and State Road 29, 18-0-6 (KO-216), E. V. & B. Komarek. HENDRY CO. Clewiston, 4 Jul 68, -8-3 (TF-411), W. W. Baker & P. Jinright. HILLSBOROUGH CO. Hillsborough River State Park, 10 miles northwest at Plant City, 10 Sep 71, 9 (+1 hatchling)-7-23 (KO-111), E. V. Komarek, Sr. H. R. State Park; 12 Oct 71, 15-0-27 along with cocoons, some with partly emerged hatchlings (RLC-84) and 13 Oct 71, 16-0-41 (RLC-88), R. L. Crawford & P. Jinright. MARTIN CO. Jonathan Dickinson State Park, near Jupiter, 14 Sep 71, 17-1-24 (KO-102B), E. V. Komarek, Sr. MONROE CO. Everglades National Park, 8 May 71, 4-4-16-2 (KO-88) and 15 Sep 71,-3-26 (KO-104), E. V. Komarek, Sr. West Pinecrest, 3 Jul 68, 17-0-0 (TF-405), W. W. Baker & P. Jinright. OKEECHOBEE CO. North Okeechobee, 4 Jul 68, 1-0-0 (413A), W. W. Baker & P. Jinright. PALM BEACH CO. South Okeelanta, 4 Jul 68, -8-2 (TF-409) and -28-1 (TF-410), W. W. Baker & P. Jinright. PASCO CO. 2-0-5 (RLC-85), R. L. Crawford & P. E. Jinright. ST. LUCIE CO. Fort Pearce, 13 Sep 71, 2-3-13 + 3 cocoons and 3 tail ends (KO-101A) and 14 Sep 71, 7-0-25 (KO-101B). Stuart, 14 Sep 71, 1-1-10 (KO-102A), E. V. Komarek, Sr. SARASOTA CO. Arcadia, 11 Mar 73, 15-1-18 (KO-211), B & E. V. Komarek, Sr. Myakka River State Park, 14 Oct 71, 60-2-92 (RLC-92), R. L. Crawford & P. Jinright. SUMTER CO. 0-0-1 (RLC-93). R. L. Crawford & P. E. Jinright. VOLUSIA CO. Daytona Beach, 10 May 68, 12-0-0. Allandale, 27 Jun 68, 12-0-0 (TF-572), 2-0-0 (TF-573) and 10-0-0 (TF-574), W. Wetherill. **WEST PAKISTAN.** Karachi, calcareous soil, 21 Dec 65, 10-6-6, A. W. Khan.

Interception: **AZORES.** From earth with one plant of *Codrylina* sp., in baggage on plane, arriving at Boston, 24 Oct 67, 7-0-1.

External characteristics: Worms from St. Lucie County, the Everglades, etc., seemed shorter than previous Florida material, 46-49 and 51-57 mm with an average length of 55.44 mm. Maximal thickness, in the clitellum and at full tumescence, 4-5 mm, average of 4.22 mm. Segment i varies from a state of complete retraction and, of course, external invisibility, to one of total protrusion as a fragile, flaccid, almost translucent tube (of little muscularity?) that may be as long as combined lengths of ii-iii. What appears to represent intersegmental furrow 1/2, at least distinctly demarcating the second segment anteriorly, often seems to be continued backward though but slightly under ii. An anteriormost portion of ii shows by numerous fine rugosities and slightly lessened firmness of the parietes there, an early stage of the rolling into the interior of the entire segment, in association with dislocation of its setae behind the segmental equator and nearer to 2/3. Segment length increases through ix-xiii, xiv is not easy to distinguish, especially if setae are lacking or unrecognizable but in some part because of being overhung (clitellate worms) by the markedly tumescent segment xv. The latter always is much shorter than xvi and even may be slightly less than half as long. Segment xxiii always is much smaller than xxii. Near the posterior end of the body segments become longer. Thus, a 10 mm fragment from the middle of the body (but not containing any part of Eisen's zone) contained 66 segments while the last ten millimeters of the same worm only had 21. Eisen's caudal zone always was present but usually lacked any special coloration.

All setae of ii and successive segments to xiv are closely paired. *AB* is gradually widened through the clitellum by lateral displacement of the *b* setae. Although the *a* setae of some of the immediately post-clitellar metameres may be slightly displaced laterally, in the remainder of the body the ventralmost rank on each side seems to be nearly straight to the very hind end, though in the last few segments, *AA* gradually does become smaller. Far posteriorly all setae become more protuberant beyond the cuticle but not perpendicularly so, being usually directed posteriorly.

Clitellum, previously characterized (Gates, 1972: 54 and 1973: 6) as saddle-shaped, definitely was completely annular on some of the smaller worms or at least partly annular in others. A distinct red color was present but probably had been developed by the preservative. (*In vivo* the color may well have been yellowish!). All of the fluid is a 200 ml jar had acquired a deep reddish color, apparently without lessening that of the clitella. The ventral bend in the clitellar region of some of the smaller worms was less marked than usual though in several it was almost J-shaped. Variation in

clitellar extent was slight; xv-xxii (12 specimens), xv-xxiii (197). Tubercula pubertatis, uncolored bands without epidermal tumescence, just lateral to *B*, in xix-xxi (122), xix-xxii (141). Intersegmental furrows 19/20-20/21 at least, sometimes also 21/22, are depressed or deepened through each tuberculum. Genital tumescences, small, transversely placed, white areas, each with a central, transversely, slit-like aperture of a "giant" setal follicle projecting conspicuously into the coelomic cavity (*cf.* fig. in Gates, 1933: 602). Locations: in sxviii, on left side only (8), right side (1), both sides (2). The immediate margin of each *a* and *b* follicle aperture of xix-xxi, occasionaly of xxii also, is white and very slightly tumescent. Associated setal follicles are slightly thickened but project into the coelom only very slightly if at all.

Internal anatomy. The intestinal typhlosole of the present worms never was found to be rolled up as in a scroll though still too high for gut diameter, but was irregularly zig-zagged, crushed together and into contact with the gut floor. Opening the intestine from the ventral side (for typhlosolar data), in such circumstances, without damaging the typhlosole, is difficult.

Seminal vesicles, strap-shaped and of firm tissue, extended through eight segments, into xx (1), fourteen segments into xxvi (1). Supraparietal, acinous glands are associated with the giant setae. Sometimes also with the smaller *a*, and *b* follicles of xix-xxii.

Distribution

Too much importance has been allowed to presence of *P. corethrurus* at "on or near beaches", in various part of the world. Years of collecting in Burma, between World Wars I and II, never provided specimens from or even near to sea beaches. Though the species has been recorded from Victoria Point at the southern boundary to Bhamo, near the Chinese frontier in the north, but mostly in the lowland districts. In India, the American worm, during World War II, already was as far from any marine beaches as it was possible to get without leaving the entire peninsula behind.

In Florida, the species already has been recorded from eighteen counties.

Reproduction

Not one of the numerous specimens that were dissected showed any evidence for amphimixis. Reproduction throughout the state of Florida, very probably is parthenogenetic.

Regeneration

No. 4. An aclitellate St. Lucie worm, 42 mm long, has a tail regenerate 7 mm long at 138/139. The anus was terminal and widely open. No. 5. An anterior substrate of 26.5 by 5 mm had a tail regenerate of 64 segments at 137/138. (The three tail regenerates of a previous contribution, Gates, 1973a, p. 9, are Nos. 1-3)

Abnormality

No. 1. In xix-xxii, each segment on the right side only and just to the tuberculum is split into two with duplication of *a* and *b* setae. From the tuberculum dorsally no trace of any doubling was recognizable on the other side in the maximally tumescent epidermis. No. 2 An extra but wedge-shaped segment is intercalated between iii and iv on the left side. On that side the clitellum and tuberculum seem to be one segment behind conditions on the right side.

Economic Importance

In many localities of Burma and the Malay Peninsula (possibly also of India), to which *P. corethrurus* certainly was introduced, probably by man and since 1500 A.D., the species is present in much greater numbers than any endemic. Indeed, perhaps greater than the number of all endemics and other exotics together. Whether human activity first reduced the populations of the natives or whether the American worms, unaided by any human activity (of course excepting the introductions), crowded out the endemics, in unknown. In widely separated parts of the world the species has been suspected of being involved in soil compaction that was harmful to agriculture.

Systematics

Lumbricus corethrurus, according to its author, was "the commonest earthworm" of Brazil, present "in almost every clod of arable land". Systematically important information about it, as provided by Dr. Müller in the original description of the species, in modern terminology, can be summarized as follows: Pigment, none. Segments, 200-250. Clitellum, in xiv-xxi. Eisen's caudal zone, of 5-10 metameres, beginning about with the 132'd segment. Setae, paired in the anteriormost segments, behind the clitellum, gradually assuming the quincuncial arrangement, in the posteriormost region enlarged, straight, markedly protuberant (bristles) and seemingly "incapable of being entirely retracted". "The stomach is strongly muscular.", the only reference to internal anatomy certainly refers to the gizzard. The "almost globular" egg capsule contains only one embryo each.

If Müller considered the peristomium, like the proctodeum, unworthy to be counted as a segment (as formerly was believed), his determination of the clitellar location, when stated in the present manner, is the same as that of this author (Gates, 1972a: 54 and 1973a: 6), *i.e.,* in xv-xxii. Similarly, there is little to question or criticize in most of the original description.

However, Müller did report: "When the animal, feeling about, extends the head, one or two similar segments, together with a clavate head lobe with a long peduncle, make their appearance from the first segment." Just what does that statement mean? It certainly merits careful consideration in the present connection.

The "head lobe" probably was considered, at least by some, to be a prostomium, which is a muscular protuberance from the anterior margin of the peristomium dorsally and so is above the mouth. Little is definitely known about its functions which may be primarily sensory, as Müller perhaps believed because of its "feeling about". The organ is almost always present in megadriles (but see other glossoscolecids below). This author, who delightedly watched in a recently seeded, city grass-plot in front of a bank in broad daylight, until ordered away by a policeman, night crawlers *(Lumbricus terrestris),* pulling up the little seedlings, long has believed the organ functions in eating like an elephant's trunk.

The "long peduncle" tempts one to wonder if a proboscis could have been involved. That would seem to be unlikely especially if the clavate head lobe was a prostomium. However, a fortuitous protuberance, even from the ventral side of the buccal cavity, superficially could have resembled a prostomium as this author has learned from his own experience.

Along with something called "one or two segments", the prostomium of Müller's Brush-tail had been completely concealed within the anterior end until the worm began to feel about. Such retention certainly must have involved modification in the external appearance of the internalized axial portion at least, if not also of the head lobe. Even one segment, plus a prostomium with a long peduncle is too much to be included within any megadrile

peristomium this author has seen. Whatever may have been involved, Müller probably did not intend to indicate that what appeared from within the interior of the body had been contained with in the first segment.

At least twice, this author has stated (Gates, 1972a: 55 and 1973a: 3), that a proboscis, as well as a prostomium, is lacking in *P. corethrurus*. Indeed, any trace of either was lacking, in every dissected specimen of a brush-tail, from various parts of India, Burma, Thailand, the Malay Peninsula, the Philippines and the United States. However, since publication of those two references, the author has seen, in preserved American glossoscolecids, more or less like the brush-tail externally, a proboscis or a prostomium, though wholly inside the anterior end and visible only in a dissection. Furthermore, the South American specialist, Dr. Righi, has reported (*in lit.* 1980), that he knows at least one species in each of four other glossoscolecid genera with a quincuncial arrangement of the setae posteriorly. Müllers study of the glossoscolecid internalia may have been very limited. His observations on live material obviously could have been made on specimens of one or more other glossoscolecids with a brush-tail arrangement of the setae. Even if some of such species had been widely exported, it does seem unlikely that they could have remained unrecognized from so many different portions of the world.

Beddard (1895) mentioned that neither he nor Perrier had been able to find a prostomium in *P. corethrurus*. Some other specialists, probably relying on Müller's original account rather than a dissection, of their own material, defined *P. corethrurus* as having a withdrawn prostomium.

Just how much internalization has the anterior end of *P. corethrurus* undergone? Probably not very much, at least as compared with some other glossoscolecids. Even though the author has seen, in some of his own specimens, "the anterior end of the digestive system everted to a distance greater than the combined lengths of segments i-iv". The mouth, in absence of a prostomium, if the species ever had one, now is terminal. The peristomium, on disappearance of intersegmental furrow 1/2, had become indistinguishable from an anterior portion of ii of variable length in which the body wall now much thinner, longitudinally and finally rugose, more like the lining of the buccal cavity. The epidermis of the shortened posterior portion of ii still resembles that of iii except that the setae now are quite close to 2/3. With loss of all setae and inability to recognize follicle appertures, a segment, which formerly was iii, might then seem to be the peristomium.

When the cephalization, already well under way in the brush-tail, is completed, the species will be defined by its gizzard being in segment iv and its calciferous glands in v-vii. Gizzard and calciferous gland locations of some other glossoscolecids are; in iii and v-vii of *Estherella* spp., or iii and iv-xi of *Thamnodriloides yunkeri* Gates, 1968. After a seemingly cephalizational loss of three segments by each species! In segments i-ii of *T. yunkeri*, a loss of much pigment, marked weakening of the parietal musculature and the appearance of longitudinally and finely rugosities, all suggest that even further cephalization is under way.

Estherella species have a proboscis but *T. yunkeri* has no proboscis or prostomium.

Thamnodrilus matapi Righi, 1969 has its testes in ix-x. Had it also undergone shortened fusion of its peristomium with segment ii?

Cephalizational elimination of a segment is not limited to the Glossoscolecidae. Two megascolecid, Burmese genera, *Nelloscolex* Gates, 1939 and *Tonoscolex* Gates, 1933, in eliminating one segment did retain a prostomium.

In spite of the efforts of distinguished specialists, Bahl, Beddard, Benham, Eisen, Horst, Perrier, Rosa, Stephenson, and many more or less futile dissections by the writer, much remains to be learned about systematically important anatomy of *P. corethrurus*. Some of the problems are listed in a previous publication (Gates, 1973a: 11).

Glossoscolecidae sp. II

Material examined: **FLORIDA.** DADE CO. Florida City, 15 Apr 74, 0-23-4 (KO-230B), E. V. Komarek, Sr.

External characteristics: Size (clitellates), 82-97 by 3-5 mm, average, 87 by 4.33 mm. Segments (clitellates), 179, 193, 197 (aclitellate), 280, 287. Segment 1, flaccid, semi-translucent and well (if not almost completely) protruded. Segment ii clearly demarcated anteriorly but with slight, short rugosities in an anterior portion of its entire circumference. Setae, small, closely paired in the first few segments, those of ii displaced posteriorly and much nearer to 2/3, recognizable (if at all) with extreme difficulty from viii or ix to xiv. *AB* gradually widening in x-xiv and obviously still wider through the clitellum. Setal arrangement becomes quincunxial behind the clitellum. However, tips of the setae were not recognized as such, only tiny, whitish, conical protuberances (of the cuticle or the epidermis?). Near the anal region, setal tips are visible as tiny black dots in equatorial circles of smaller white markings that produced a distinct appearance as when the setal arrangement is perichaetine. But examination under the microscope of detached cuticle revealed nothing that could have the perichaetine appearance. Presence of Eisen's zone is indicated by a local thickening of the body but because of absence of any special colour it may be difficult to distinguish from other short areas of local thickening. Nephropores, obvious, even in the last few segments, in a single row on each side.

Clitellum, probably not at maximal tumescence, apparently annular but the epidermis certainly is thinner in the ventrum of *BB*, color a light pink, im xv-xxiii (4). Segments immediately in front of the clitellum are not as short as in *P. corethrurus*. The first and last clitellar metameres also seem to be longer than in the other species. Tubercula, lacking (?). Genital tumescences very small, whitish rims around each of the unenlarged or only very slightly enlarged apertures of the *a* and *b* follicles in each of xix-xxii. A ventral bend in the clitellar region is lacking or too slight to be noticed.

Internal anatomy: A proboscis is lacking. When a midventral incision is made back from the mouth and the sides of the body are pulled apart, a broad fleshy lobe, 1+ mm wide transversely, becomes visible. It is attached to the body wall dorsally at level of 2/3 and is above the brain which is on the anterior face of the pharyngeal bulb.

Four thickly muscular septa, presumably 6/7-9/10 (assuming the gizzard is in vi) are present. Calciferous glands, in number, location and structure are as in *P. corethrurus*, except for absence of the distal appendage. An esophageal valve was not recognized and if present must have been very short. Intestinal origin, in region of xiv-xv (?). Typhlosole, beginning in region of xx, 4+ mm high, irregularly folded and ending in Eisen's zone, is segments 110-117 of 287, 110-119 of 193, 109-116 of 197. A narrow band of yellowish material is present on the gut along each side of the dorsal blood vessel from the beginning of the typhlosole. The dorsal blood vessel is deeply constricted so as to have two or three moniliform sections in each of segments x-xiii. The subneural trunk is on the parietes.

Seminal vesicles, lacking. Spermathecae, as in *P. corethrurus*. TP gland was supraparietal on the left side only of each of two worms on which tubercula actually were unrecognizable. Ventral

follicles of *a* and *b* in each of xix-xxii are slightly thickened and their ental ends are visible in setal gaps of the musculature, but there is no protuberance above the peritoneal level. The setae of those follicles have lost most of the sigmoid shape but are not exactly straight. The ectal ends are claw-shaped and the ornamentation is of the usual longitudinal rows of gouges.

Abnormality

Spermathecae of ix (1 specimen) are unusually short, with the well differentiated ampullae of the same length as the duct.

Parasites

Small cysts (gregarine?) fill coelomic cavities in the last four segments. (1 specimen).

Systematics

The fleshy lobe on the roof of the buccal cavity, in these worms, is too constant to be dismissed as fortuitous. Classical specialists presumably would have regarded it as a retracted prostomium (see p. 21). Whether it can be partly or wholly protruded, from a level that appears to be posterior to that of a similar structure in moniligastrids, cannot be satisfactorily determined in dissections of preserved specimens. It does look larger than any external prostomium the author has seen on similar-sized worms. No trace of any former connection with the anterior margin of an individuals peristomium was recognized. Is it really a formerly external protuberance from the anterior margin of a peristomium that now is very weak and flaccid. Or is it locally developed within the buccal cavity and a definitely new organ?

The available material, even though not fully mature, must be assumed to be parthenogenetic, because of absence of any evidence for male fertility. What anatomical changes may have appeared, since parthenogenetic reproduction became possible, can only be guessed until an amphimictic parental population has been recognized.

Systematically important, somatic differences from *P. corethrurus* are: Presence on the roof of the buccal cavity of a fleshy lobe vaguely suggesting an enlarged prostomium. Marked differences of the setae in the posteriormost segments. Absence of a distal appendage on each calciferous gland. Determination of genital differences certainly awaits recognition of an amphimictic population of *corethrurus*.

Errata

One specimen from the Florida City batch, with an abnormal growth of the intestinal region, was sent, without a label to New Brunswick, where Dr. Reynolds had it photographed. On its return to Bangor, the worm unfortunately was placed in a tube, labelled, "*Diplocardia* sp., Texas, Sanders." From that label was taken the information too hastily provided along with the illustration (in Gates, 1977c: 70). Mr. Sanders denied having any responsibility for the worm which was then rescued from the *Diplocardia tube*. A slight ventral incision of the anterior end, revealed a characteristic, fleshy protuberance at the proper site on the roof of the buccal cavity. The species is the only Florida glossoscolecid with such a buccal organ (?).

Glossoscolecidae sp. III

Material examined. **FLORIDA.** DADE CO. Florida City, 6 Dec 67, 2-5-9 (TF-507), E. V. Komarek, Sr.

External characteristics: Size, 85-105 by 7-9 mm. Segments, 167 (posterior amputee?), 216, 219, 221, 223, 224, 228, 232, 257. Peristomium, seemingly less than one fourth the length of the next metamere but probably not quite so short because of being overlapped by ii, often partly or wholly concealed by protrusions of the buccal cavity, with numerous, slight, longitudinal rugosities, but with a firm texture more like that of ii and much less like the flaccidity of the buccal protrusions. Segment lengths; of ii, 1+ mm of iii-iv 1+ to 1.5 mm, of v-viii, 1+ mm, of ix, < 1 mm, of x-xi obviously much shorter, of xii slightly longer than xi, of xiii still longer, of xiv-xxii 1+ mm, of xxiii about the same as or slightly shorter than xxii, of the next few postclitellar segments the shortest of all, then gradually becoming longer, with greatest length near the hind end. A markedly protuberant circumferential ridge, just in front of a segmental equator, is present in each of ii-viii or ix. Prostomium, none. Anus, a vertical slit on posterior face of the soma, bordered by small, white, left and right lips with rugosities. Color, white, except in clitellum which is a brownish yellow. Eisen's zone, lacking (or unrecognized?), also a prostomium.

Setae, retracted in most of the body, small, tips certainly recognizable only with higher powers of the microscope, unrecognized in ii-viii or ix. Those in line with the nephropores of ix or x to the clitellum may be of the *d* rank. If so, those somewhat mesially to the nephropore levels may be of the *c* rank. Setae certainly referable to the *a* and *b* ranks were not recognized until behind the clitellum where the arrangement gradually becomes quincunxial. Setae in the last twenty or more segments are enlarged, conspicuously protuberant posteriorly, with markedly hooked tips. The last segment usually has only seven setae though an aperture of an empty follicle sometimes is visible.

Nephropores, obvious, crescentic slits, about at mL, present from iii. Dorsal pores, none.

Spermathecal pores, three pairs, at 5/6-7/8, in front of the nephropores. Male pores(?), minute, superficial, paired, each in a slight depression within a small whitish area just in front of 17/18 (1), at or very slightly in front of eq/xvii (2 specimens). Clitellum, intersegmental furrows not yet obliterated, annular anteriorly, lacking (not yet developed?) between the tubercula and posteriorly, in xiii-xxiii (8). Tubercula pubertatis, three pairs, in xix-xxi (8), each a conspicuous, white subspheroidal protuberance with a band of special brilliance laterally, those of a pair widely separated.

Internal anatomy: Septa, 4/5 membranous, 5/6-10/11 rather thickly msucularized, 11/12 membranous and closely applied usually to 10/11. Buccal cavity and pharyngeal bulb, 5 mm long, the bulb much more definitely delimited dorsally than is usual in other families, about the size of, and at first glance seemingly like a gizzard. Proboscis, 2-3 mm long, usually deeply withdrawn into its sheath so that its anterior end is about at level of eq/ii, in four of the specimens, protruded to the exterior. Postpharyngeal esophagus looped, the total length of gut in front of 5/6, 12+ mm. The gizzard, massive, just in front of 5/6, at least 3 mm long. The postgizzard esophagus, without recognizable calciferous glands, is short, straight, high up in the coelom. Intestinal origin, in xv (?). Typhlosole, simply lamelliform but of a height greater than diameter of the gut lumen compelling irregular folding, ending abruptly in region of the 120th-136th segments leaving (Table 2) 93-117 metameres atyphlosolate.

Dorsal blood vessel, usually blood-filled in a posterior portion of the body, lacks the clitellar-region constrictions of *P. corethrurus*, but seems to pass on one side just in front of the intestinal origin though continued anteriorly but with little or no blood. The ventral

Table 2. Typhlosole termination and segment number in Glossoscolecidae sp. III.

Typhlosole ends in segment	Number of atyphlosolate segments	Number of segments in soma
120	117	237
123	98	221
130	93	223
130	102	232
136	31	167[1]

[1]This worm lacked obviously enlarged setae posteriorly and at first was suspected of belonging to another species. The worm probably is a posterior amputee.

trunk is high up in the coelom. Segmental commissures of vi-viii are slender. Hearts, two pairs, large, in ix-x. A conspicuous connection between dorsal and ventral trunks in xii is much slenderer than the hearts. Extra-esophageals, each formed anteriorly by union of two major vessels, unite medially on ventral face of the gut just in front of 5/6. Subneural trunk, not found.

The anterior nephridia are in a large mass on each side of the pre-gizzard esophagus. From the anteriormost portion of each mass a duct passes forward to the pharynx lateroventrally. Another duct from a major middle portion passes to a nephropore of iii. A similar duct from a small, posterior portion of each mass passes to a nephropore of iv.

Gonads and gonoducts were not found. A pair of empty sacs in each of ix and x may have been testis sacs in which a gonad had failed to develop. Spermathecae, juvenile, flat, ampullae empty, in vii-viii. Seminal vesicles, very thin discs, flattened against posterior faces of 9/10-10/11, presumably are vestigial.

Reproduction

The worms obviously are male sterile. The juvenile spermathecae indicate that no sperm had been received in a copulatory act. In such conditions, reproduction must be parthenogenetic.

Parasites

Rather small, spheroidal cysts were common. One worm was allowed to soften in water until an odor was detected. Then a stick of caustic potash was propped against the wall of the jar. When next seen the whole stick had dissolved and the worm had been reduced to a flocculent debris in which no setae were visible. The white cysts seemingly had not been affected by the potash. Still opaque, lactophenol was added for clearing but the cysts then dissolved with release of many bubbles.

Systematics

The peristomium at first glance usually appeared to be shorter than it really is, because of being overlapped by ii as well as partially concealed occasionally by everted buccal protuberances, but even so may be slightly shorter than normal. Numerous, slight, longitudinal rugosities that often are associated with a marked weakening of parietal musculature of internalization, also were present. Nevertheless, the peristomial texture was just as firm as that of ii. Demarcation from ii was by a circumferential furrow that is just as distinct as any of the subsequent intersegmental furrows. Secondary furrows are lacking in both i and ii. The condition of the peristomium is such as to warrant a suspicion that it is on the way to disappearance whether or not internalization is involved.

The first postgizzard septum, thickly muscular in the Florida glossoscolecids, is inserted on the parietes over intersegmental furrow 5/6. No evidence for any displacement of the septal insertion was recognized. Accordingly, the unusually massive gizzard is in v, one segment anterior to its usual location in glossoscolecids. Though gonads were unrecognized, membranes thought to be of empty testis sacs were found in segments ix and x, also one segment anterior to their expected location. Supposed vestiges of seminal vesicles supported the testis sac interpretation. One whole segment must then have disappeared from the anterior end, without leaving any otherwise recognizable evidence for its former presence. And the appearance of the peristomium seems to suggest that the process is to be repeated.

Each worm seems to require reference of the species to the Glossoscolecidae. Which then requires deletion of one somatic character, the author had thought (1972a: 53) to be definitive for the family: "with paired extramural calciferous glands in some of segments vii-xiv or their homoeotic equivalent".

Glossoscolecidae sp. IV

Material examined: **FLORIDA.** DADE CO. Homestead. 19 Jan 67, 7-1-0 (TF-103), E. V. Komarek, Sr. (These worms were from such a stiff soil they had to be dug out with a pick axe, and were in poor condition. Perhaps as a result of having died before preservation. After a drastic dissection of each specimen, they were discarded, as of no further use.)

External characteristics: Peristomium, with numerous rugosities but delimited anteriorly by a completely circumferential furrow, from the slightly everted buccal cavity. The segment next behind not only is setigerous but all are equatorial. Combined length of the first two metameres slightly less than 2 mm. Secondary annulation, none. Prostomium, none. Dorsal pores, none. Color, white. Setae, apparently smaller than in *P. corethrurus,* but even so, the ventral ranks (aside from occasional exceptions) are each at a single level, all the way to the hind end. Nephropores, obvious, about at *C.* Genital tumescences, slight, around apertures of the following setae; *a*/xii-xiii, *b*/xii-xiii (with *b*/xii out of line), *b*/xxiv (also out of line), *b*/xxv, *a*/xxxi, xxxiii.

Internal anatomy: Proboscis, completely retracted, with 7-8 annuli, length 2+ mm and so longer than combined lengths of i-ii. Septum 5/6 and several subsequent septa thickly muscular, large, funnel-shaped and posteriorly directed centrally.

Gizzard, in v. Calciferous glands, small, low down in the coelom, each opening from its ventral end and without obvious duct, into the esophagus near mV. Typhlosole, beginning well behind intestinal origin, simply lamelliform, rather high but not enough to need being rolled up into a scroll, but slightly folded in a zizag manner. For the first few of its segments associated with a smaller lateral typhlosole on each side. Dorsal trunk, single, much thickened and markedly moniliform in xiii-xxxi. Subneural, adherent to the parietes.

Spermathecae, first pair passing into parietes immediately in front of 6/7 (but opening to exterior at 7/8?), second pair immediately in front of 7/8, 10+ mm long, duct looped, ampulla small, probably contracted. Male funnels, in xi, large, much folded, with marked spermatozoal iridescence. Seminal vesicles, slender, moniliform because of septal constrictions, reaching back (one worm) into the 140th segment. Testes and ovaries, not found.

Reproduction

Because of the maturation of sperm, is expected to be amphimictic, if copulation is possible (male gonoducts and male pores as well as female pores not found).

Systematics

Even though internal structure of the calciferous glands is unknown, their mode of discharge into the gut, distinguishes the worms, though all are immature, from each of the presently-known, Florida glossoscolecids.

Glossoscolecidae sp. V

Material examined: **FLORIDA.** DADE CO. Princeton, 15 Sep 71, ?-2 (2?)-4 (KO-105), E. V. Komarek, Sr. (The worms were soft and fragmented easily during examination. They may have died before being preserved.)

External characteristics: Size, to 134 by 6 mm. Segments, 560, very closely crowded behind clitellum to the last twenty which become longer (as a result of greater relaxation or perhaps of some *post mortem* change). Prostomium, none. Color, white. Setae, small, very slightly if at all protuberant from the cuticle, unrecognizable from the coelomic side of the body wall, in quincunx arrangement from shortly behind the clitellum. Though with occasional gaps, the *A* rank seems to be almost straight to the hind end. Nephropores, obvious, in a single regular, longitudinal rank on each side of the body. Clitellum; (xvi-xvii?) xviii-xxxiii (No. 1, saddle-shaped but epidermal tumescence slight, probably not fully developed), (xviii?)xix-xxxiii (No. 2, seemingly annular), (xvi-xvii?)xviii-xxxiii (No. 3), (xviii-xix?)xx-xxxiii (No. 4, annular). The color is a deep red. Segments in parentheses, as well as xxxiv-xxxv, once even xxxiv-xl, are unusually short but did have some slight pinkish color that may have appeared after preservation. Tubercula pubertatis, broad, white bands of seemingly non-tumescent epidermis, in xxvi-xxxi (1 specimens), xxvi-xxxii (3). Genital tumescences, recognizable before the tubercula, located as follows: *a,b*/xii-xiii, xxiv-xxvi, *a* only xxxi-xxxiii, (No. 1); *a,b*/xii-xiii, *b*/xxiii, *a*/xxiv, *b*/xxiv, *a*/xxv, *a*/xxxiii (No. 2); *a*/xxiii-xxvi, *b*/xxiv, *a*/xxxiii (No. 3); *a,b*/xiii, (*a,b*/xi-xii?), *a,b*/xxiii-xxvi, *a*/xxx-xxxii, (No. 4), *a,b*/xi-xiii (1 aclitellate), *a,b*/xii-xiii (1 aclitellate).

Internal anatomy: Proboscis, always completely retracted and invisible until the anterior end is opened, to 3 mm long, rod-like, within a tube that reaches back above the brain and onto the pharynx to the anterior margin of iv. Septa, 6/7-10/11 enlarged, muscularized, funnel-shaped, thickness decreasing through 10/11-11/12. Strong, longitudinal muscular cords pass through those septa underneath the gut and to parietal insertions in region of xv.

Esophagus, between pharynx and gizzard thin-walled and 3-4 mm long, in each of the very short coelomic spaces of ix-xii widened equatorially, highly vascularized, and with irregular, non-lamelliform ridges internally. On and between those roughenings of the gut wall, were tiny, white granules that may have been calcareous. An esophageal valve, if present, must have been so short as to be unrecognized. Intestinal origin, in xvii or xviii(?). Typhlosole, simply lamelliform, beginning rather abruptly in the region of xxx, 1.5-2 mm high, still present in the 212th segment of a posterior amputee. Gizzard well developed in vi.

Dorsal blood vessel, with that portion belonging to xiv-xviii much elongated, distended, transversely placed in each metamere, constricted into bead-like sections. Subneural trunk, wherever recognizable, is parietal. Hearts, large, in x-xi, esophageal(?). A large mass between hind end of the pharynx and the gizzard, on each side, seems to be composed of only a single large tubule. If nephridial, it would seem unusually thick.

Male funnels, one pair, large, much crenellated, reaching up into contact with dorsal parietes, in xi (2 specimens). Seminal vesicles, one pair, extending from xiii through at least 25-30 segments, as ribbon-like bands against lateral faces of the gut, then gradually becoming larger, along with much twisting and folding until coelomic cavities between gut and body wall seem to be filled, continued in one worm into segment cxii. Male gonoducts, super-superficial but covered by the nephridia. Spermathecae, three pairs, in vii-ix, translucent to transparent and empty, slender, to 3-4 mm long, an entalmost portion is slightly widened into what may be the ampulla (or an ellipsoidal seminal chamber).

Reproduction

Slight iridescence on male funnels of one worm, showed that some sperm already had been matured. No iridescence was noted in any other worm, even in one that did have a white coagulum in its spermathecae.

Ingesta

A triangular piece of black material with sharp corners, 2.25 mm long, was present in the thin-walled pre-gizzard esophagus. Similar angular fragments of the same sort of substance, perhaps bark, were in the gizzard as well as through the intestine of the same worm.

Parasites

Two microscopic nematodes were seen in a fragment of tissue that may have been nephridial. Coelomic cavities of the hinder portion of an aclitellate worm were packed with (gregarine?) sub-spheroidal cysts, 0.5-1 mm thick. Fewer but small cysts were in immediately postclitellar segments. Small cysts were present in a tail fragment, perhaps of a juvenile.

Although available information does not warrant identification or naming any taxon that may be new, each of the five Florida glossoscolecids is readily distinguishable. The following key is provided in hope of speeding the accumulation of information that will enable the proper systematic treatment of four interesting glossoscolecids.

Key to the glossossolecids of Florida

1a. No prostomium, proboscis or any trace of them[13] .... *P. corethrurus*
b. A prostomium-like process or a proboscis present dorsally within the anterior end of the body 2
2a. A prostomium-like process present ..... Gl. sp. II
b. A proboscis present 3
3a. Gizzard in segment v 4
b. Gizzard in segment vi ..... Gl. sp. V
4a. Calciferous glands lacking ..... Gl. sp. III
b. Calciferous glands present ..... Gl. sp. IV

Glossoscolecidae *gen. et sp.*

Interceptions: **BRITISH VIRGIN ISLANDS.** From 25 pounds of earth in cargo on sloop, May Rose, arriving at Charlotte Amalie, 3 Nov 53, 13-0-5. **CANAL ZONE.** From orchid fibre in mail arriving at Washington, D.C., 26 May 49, 2-0-0. **COLOMBIA.** From earth on roots of orchid plants *(Miltonia)* in passenger's baggage arriving at Hoboken, 23 Sep 53, 2-0-0. **COSTA RICA.** From orchid plants in cargo arriving at plant inspection station, Hawaii, 7 Jul 53, 1-0-0.

[13]Easily determined by making, with fine scissors, scalpel or other sharp edge, a short cut at mV from the anterior end so as to fold back the cut edges and look into the buccal cavity.

From 30 pounds of earth with *Musa* sp., in baggage on American OS Corsair arriving at San Diego, 31 May 54, 0-0-1. From 484 plants (Orchidaceae) in cargo on plane arriving at San Pedro, 14 Jan 57, 1-0-0. From 4 pounds of earth with unidentified plants in baggage on plane arriving at San Pedro, 16 Sep 61, 0-0-2. **GUATEMALA.** From 40 pounds of earth with *Ceiba petandra* in cargo arriving at San Pedro, 3 Aug 55, 1-0-0. **HONDURUS.** From earth in baggage on SS Contessa arriving at New Orleans 16 Mar 50, 4-0-0. **MEXICO.** From earth with plants in passenger's baggage arriving at Nogales, 5 Jan 53, 3-0-0. **NICARAGUA.** From 5 pounds of earth around roots of plants in baggage on plane arriving at San Pedro, 12 Sept 50, 1-0-0. From earth with roots of avocado plant on plane arriving at Brownsville, 4 Mar 57, 5-0-0. **PANAMA.** From soil around begonia roots on plane arriving at Houston, 19 Jun 49, 2-0-0. **PUERTO RICO.** From 80 pounds of earth with Croton plants (*Codiaeum* sp., Euphorbiaceae) in baggage on M/V Emilia arriving at Philadelphia, 28 May 60, 1-0-0. **PERU.** From earth of potted plant in passenger's baggage on SS Gulf Banker arriving at Galveston, 3 Aug 52, 9-0-0. From plants in cargo on plane arriving at Honolulu, 19 Feb 64, 1-0-0. From 27 bromeliad plants in cargo on plane arriving at Honolulu, 17 Sep 64, 1-0-0. From earth with unidentified plant on plane arriving at Honoluly, 19 Feb 64, 0-1-0. **TRINIDAD.** From earth with 2 *Mucuna bennettii* in cargo on plane arriving at Washington, D.C., 18 Aug 48, 1-0-0. **VENEZUELA.** From roots of Eriocaulaceae *sp.*, in passenger's baggage arriving at Hoboken, 31 Mar 55, 1-0-0.

Present knowledge of most glossoscolecid species is insufficient to allow identification of the above immature worms. An aclitellate worm (in poor condition) intercepted at Hawaii may have had a pair of slight furrows (seminal?) lateral to *B*, in xx-xxiii. It did have a tail regenerate of 63 segments at 49/50.

In the not so distant past, glossoscolecids II-V might have been suspected of being endemic and might even have been described as and named as new. Even if the four Florida species still are unnamed, they now have been described and presumably can be recognized. Even if they are unknown in their original countries they could have been recently imported to Florida, as the interceptions listed above and in a previous contribution show (Gates, 1973a: 3).

SUPERFAMILY LUMBRICOIDEA

This holarctic taxon, uniquely, is distinguished from all other megadrile groups (Gates, 1976: 1) by its ovaries, which are: small, disoidal, ending distally in a single egg string. Also characteristic, though less so, is the lack of any spermathecal diverticulum, a condition which is shared with the previous superfamily, as well as most species of one megascolecoid family, the Ocnerodrilidae.

Of the six lumbricoid families, two (and three subfamilies) are purely European, none of their species having obtained, or been given, domicile elsewhere.

KOMAREKIONIDAE Gates, 1974

The single species, *Komarekiona eatoni* Gates, 1974, has been recorded from scattered counties of five states; Illinois (1 county), Indiana (1), North Carolina (6), Tennessee (4), Virginia (1). Reproduction, below (or east of) the Appalachians, insofar as is now known, supposedly is amphimictic though Reynolds (1977: 67) found no confirmation as all his material from four counties of North Carolina and one of Virginia was immature.

Sims (1980: 108) thinks that similarities (mostly in the genitalia?) with the European *Ailoscolex* Bouché, 1969), warrant inclusion of the American species in the otherwise European family Ailoscolecidae. The somatic differences, in view of the distance, seem more important to the author.

Above (or west of the Appalachians), reproduction necessarily is parthenogenetic because of absence of spermathecae and of matured testes. Could parthenogenesis be optional in the supposedly amphimictic forms? Could the species have survived rigors of the recent glacial era in several isolated localities of Tennessee by becoming parthenogenetic? Illinois and Indiana records obviously resulted from transportation, and presumably from Tennessee.

LUMBRICIDAE
LUMBRICINAE

This holarctic taxon is distinguished from the other lumbricid and definitely European subfamily (Sims, 1980: 109) as follows: 1) By presence of intersegmental pores opening into coelomic cavities at mD. 2) By confinement of the "single gizzard" to a single segment.

The author has been unable to convince himself that any lumbricin gizzard is entirely within a single segment. Superficially at least, the gizzard does seem at first glance, to extend, usually through xviii as well as xvii. However, when external appearances are ignored and the gut is opened (by a horizontal-longitudinal section or any other method) the brightly glistening, special muscularity of a gizzard obviously does not reach the level of 18/19. But, where does it end? Answering that question is difficult because of the fragility of the membranous septum 17/18 and its usual fenestration near the gizzard. Just by opening and pinning out the earthworm, no matter how carefully, the delicate septum often is so damaged that its insertion on the gut no longer is recognizable. The former site of that insertion then can be estimated only from the intact portion of 17/18 or by the insertion of the latter on the coelomic face of the body wall.

The giceriate portion of the gut in all other megadriles seen by the author, is definitely limited segmentally. In the classical genus, *Pheretima*, the single gizzard has been variously said to be in viii, ix, or even in x. Septum 8/9, or 8/9-9/10, may be lacking but the circulatory system shows that the gizzard belongs morphologically to viii. Whenever 8/9 is present, it clearly is inserted on the gut behind the gizzard. In other megadrile genera, additional gizzards, when present, also are segmental. They usually are in consecutive series, rarely as many as 8-9, but always are separated from each other by a short alimentary annulus in which the gizzard muscularity is lacking. The exceptional moniligastrid, *Drawida nepalensis* Michaelsen, 1907, has 2-4 gizzards, one or more of which may not be in consecutive segments. Intrasegmental restriction had been so usual in the author's experience that especially careful investigation in the lumbricids seemed desirable when such material subsequently became readily available after World War II. Randomly selected records of gizzard location in several lumbricid species and the number of specimens on which the determination was made are as follows:
Lumbricus festivus (26 specimens), "mainly in xvii" (Gates, 1978a; 99)
Lumbricus rubellus (83+) "mostly in xvii" (Gates, 1978a: 103)
Dendrodrilus rubidus (100+) "mainly in xvii" (Gates, 1979a: 133)
Allolobophora chlorotica (44+) "mostly in xvii" (Gates, 1980a: 182)
Octolasium complanatum (21) "in xvii+" (Gates, 1980b: 207)

The quoted phrases, as in the author's descriptions of various other lumbricids, are also followed by some such explanation as "the gut layer with brilliant muscular sheen narrows rapidly behind insertion of 17/18" (Gates, 1980b: 207).

The lumbricid genera *Eisenia* and *Eisenoides*, were recently defined by the author as having the gizzard "mostly in xvii". The *trapezoides* species-group, now in *Aporrectodea*, could (or should) have been similarly defined. The somewhat aberrant *Murchieona* was defined as having its gizzard in xvi-xvii (Gates, 1978a: 114). In the two available specimens of *Kritodrilus calarensis* (Tétry, 1944)

the gizzard was in xix but "possibly reaching slightly into xx". Unfortunately, nothing seems to have been recorded about septum 19/20 and its insertion on gut and parietes (Gates, 1979c: 1).

Even when gizzard penetration into a succeeding lumbricid segment could not be established, the special gizzard muscularity seemed to extend exactly to the insertion of 17/18 or at least to its probable insertion. There seemingly was no agiceriate annulus in front of the posterior septum, such as usually is distinguishable in megascolecid and moniligastrid earthworms.

In 45 specimens of *Eiseniella tetraedra* (Savigny, 1826) in which 17/18 was not fenestrated and its insertion on the gut was recognizable, the gizzard did seem to be confined to xvii but certainly was "weak" (Gates, 1977:75) as if it were being reduced. Whether the special muscularity reached the insertion of 17/18, as in other lumbricids, unfortunately was not recorded. Had the organ already undergone some posterior shortening, in *E. tetraedra?*

As already indicated, a gizzard reaching to a posterior septal insertion, or beyond, has been seen by the author only in lumbricids. He would not be surprised by a single gizzard extending in some lumbricid through two consecutive segments such as xvii-xviii or xviii-xix. And of course without any interruption by an agiceriate gut annulus.

The Ailoscolecidae, as defined by Sims (1980: 108), has two, discrete gizzards "the first in vi, vii and the second in viii, ix". Presumably between the two gizzards (each of which is uninterrupted by any agiceriate gut annulus) there is a demarcating, agiceriate, gut annulus. Although esophageal rather than intestinal as in the lumbricids, the definite, intrasegmental restriction of all other megadriles is also lacking in the Ailoscolecidae. Does not that agreement, in spite of the difference in anteroposterior location, indicate that the Ailoscolecidae is more closely related to the Lumbricidae than is the Komarekionidae?

The family Lumbricidae is represented in the continent of North America solely by the subfamily Lumbricinae with twelve genera. Ten of which, with 24 species are European (palearctic). Each of them was introduced accidentally, by man, to the continent since 1492:

Allolobophora Eisen, 1893
chlorotica (Savigny, 1826), the generotype.

Aporrectodea Örley, 1885
icterica (Savigny, 1826)
limicola (Michaelsen, 1890)
longa (Ude, 1885)
moebii (Michaelsen, 1895)
rosea (Savigny, 1826)
trapezoides (Dugès, 1828) the generotype.
tuberculata (Eisen, 1874)
turgida (Eisen, 1873)

Dendrobaena Eisen, 1873
attemsi Michaelsen, 1902
octaedra (Savigny, 1826) the generotype.

Dendrodrilus Omodeo, 1956
rubidus (Savigny, 1826) the generotype.

Eisenia Malm, 1877
foetida (Savigny, 1826) the generotype.
hortensis (Michaelsen, 1890)
(veneta)[14]
zebra (Michaelsen, 1902)

Eiseniella Michaelsen, 1900
tetraedra (Savigny, 1826) the generotype.

Lumbricus Linnaeus, 1758
castaneus (Savigny, 1826)
festivus (Savigny, 1826)
rubellus Hoffmeister, 1845
terrestris Linnaeus, 1758 the generotype.

Murchieona Gates, 1978
muldali (Omodeo, 1956) the generotype.

Octolasion Örley, 1885
cyaneum (Savigny, 1826)
tyrtaeum (Savigny, 1826) the generotype

Satchellius Gates, 1975
mammale (Savigny 1826) the generotype.

In marked contrast there are only two American (nearctic) genera, one with but two, little known species, the other known only from parthenogenetic morphs, some nine or more of which have been regarded as species:

Bimastos Moore, 1893
beddardi (Michaelsen, 1894)[15]
gieseleri (Ude, 1895)
heimburgeri (Smith 1928)[15]
longicinctus (Smith & Gittins, 1915)
palustris Moore, 1894[15] the generotype
parvus (Eisen, 1874)
tumidus (Eisen, 1874)[15]
welchi (Smith, 1917)
zeteki (Smith & Gittins, 1915)

Eisenoides Gates, 1969
carolinensis (Michaelsen, 1910)[15]
lönnbergi (Michaelsen, 1893)[15] the generotype

Is the last American glaciation responsible for the reduction of *Bimastos* (perhaps along with representatives of other genera) to a group of parthenogenetic morphs? Did that same glaciation exterminate nearly all species of a once, much larger *Eisenoides?* How or where did *carolinensis* and *lönnbergi* manage to survive the rigors of that glaciation, while maintaining their amphimixis? Neither American genus seemingly ever reached the Pacific coastal refugium (Gates, 1979b) where the megascolecoid *Argilophilus*, Eisen 1893, was dominant, at least until introduction by man of various European, Asiatic and other megadriles.

Also unexplained as yet, is the absence of endemic American earthworms in a large, inland area variously known in the past as the Great American Desert, the Great Plains, The Prairies, the Great Basin. Exotic megadriles, lacking like all other megadriles, when the area was first settled by Europeans, now are flourishing (Gates, 1967) wherever moisture is adequate for the completion of their life cycles. Yet to be investigated is the role of irrigation in the spread of those exotics.

Aporrectodea Örley, 1885

The records below inadvertently were omitted from a previous publication (Gates, 1972b). Some are first records for certain countries.

[14]For an explanation of omission of *veneta* or *venetus;* see footnote at bottom of right column, Megadrilogica (1978), 3(8): 146.

[15]Types in Europe.

Aporrectodea longa (Ude, 1895)

Interceptions: **MEXICO.** From earth in passenger's baggage arriving at Nogales, 13 Dec 53, 5-0-0. From earth with cacti arriving at Nogales, 1 Aug 55, 1-0-0. **EIRE.** From 116 pounds of sod from Shannon in cargo on plane arriving at New York, 26 Mar 62, 1-0-0. **ENGLAND.** From earth with plants in passengers baggage on SS Queen Mary arriving at New York, 5 Dec 54, 2-0-0.

Aporrectodea trapezoides (Dugès, 1828)

Interceptions: **MEXICO.** From earth with 2 plants of *Jasminum* sp., from Navajoa in baggage on auto arriving at Nogales, 17 Apr 66, 1-0-0. From 4 pounds of earth with pine needles in baggage on auto arriving at Nogales, 16 Jan 67, 16-4-6-1. **ITALY.** From earth with 1 plant of *Philodendron* sp. in baggage on plane arriving at Boston, 29 May 59, 0-0-1. **LEBANON.** From earth with an undetermined, rooted cutting of one plant in baggage on plane arriving at Boston, 16 Aug 67, 0-0-1.

Aporrectodea tuberculata (Eisen, 1874)

Interception: **AUSTRIA.** From 1 pound of earth with a plant in baggage on plane arriving at Philadelphia, 12 Jan 67, 0-0-0-1.

Aporrectodea turgida (Eisen, 1873)

Interception: **ITALY.** From earth with 1 plant (Umbellifera?) in baggage on plane, It, AZ-630, arriving at Boston, 18 Aug 70, 4-0-0.

Dendrodrilus Omodeo, 1956

Dendrodrilus rubidus (Savigny, 1820)

Material examined: Toilet bowl, residence, Newton, Mass., 0-0-0-1 (+ numerous others in too poor condition to be identified but probably of the same species), 10/Apr/79, *per* H. W. Levi. (Provided by the consulted plumber who had never heard of earthworms in toilets!) The author has seen several such records. If *Dd. rubidus* had been recorded only from an occasional individual found in a toilet bowl or tank, the species might well have been thought to be aquatic. But is any megadrile ever really aquatic? Though recorded to date only from springs, cave pools, wells, *etc.* especially only as occasional individuals.

Octolasion Örley, 1885

If the "unequalled chaos" of lumbricid laxonomy (Ljungström, 1972) is to be resolved, past reliance on invalid assumptions (Gates, 1972: 29, Nos. 1-11) must be abandoned. Taxa must be defined by characters that are invariable in each normal member of the unit that is involved. All pertinent material of *Octolasion* that was available has been studied (Gates, 1978 and 1980, Bull. TTRS. No. 14: 29-50 and Megadrilogica 3 (12): 205-211). The genus can now be defined as follows.

Digestive system, with a calciferous gland of intramural longitudinal chambers that open into the esophageal lumen anteriorly and indirectly through a pair of vertical sacs evaginated midsegmentally from the gut in x and with secreting lamellae ending on the posterior wall of each sac, a terminal esophageal valve in region of insertion of septum 14/15, intestinal origin in xv, a single gizzard extending through all of xvii and reaching slightly into xviii followed by an intestine which from region of segments xx-xxv has a ventrally bifid, dorsal typhlosole. Vascular system, with dorsal, ventral and subneural trunks, the latter on nerve cord (instead of on the parietes), paired extra-esophageals that are median to the hearts and open in the dorsal trunk in segment xii, without any supra-esophageal vessel, last pair of hearts (all lateral) in xi. Excretory system, of holoic, vesiculate nephridia, bladders behind xv elongately ocarina-shaped and with a short, funnel-shaped duct passing from the vesicle floor into parietes in region of *B*, nephropores obvious, alternating irregularly and often with asymmetry between two levels on each side of the body, one at or near *B*, the other in *DD* but usually nearer *D*. Setae, sigmoid and simply pointed, eight per segment, behind the clitellum not closely paired. Dorsal pores present at m*DD*, beginning in the preclitellar region. Prostomium, epilobous.

Reproductive apertures, all minute and paired, spermathecal pores intersegmental, female and male pores equatorial in xiv and xv respectively, all well anterior to the multilayered, saddle-shaped clitellum of more than four segments. Tubercula pubertatis, longitudinal bands extending through several clitellar segments lateral to *B*. Prostates with muscular ducts lacking. Spermathecae adiverticulate. Ovaries, in xiii, small, each ending distally in a single egg string.

Octolasion as so defined, at present contains only *cyaneum* (Savigny, 1826), *complanatum* (Dugès, 1828) and *tyrtaeum* (Savigny, 1826). How many species referred in the past to the genus, now belong there will not be known until genital as well as somatic systems have been more adequately characterized.

The definition may seem unnecessarily extended. Perhaps it is, or will be found to be so in the future. Many of the above-listed characters had already been found to be equally applicable to all lumbricids the author studied. If unexpected exceptions do not turn up subsequently in other lumbricid genera, such characters, in part or *in toto*, will belong in any definition of the subfamily Lumbricinae, if not also of the family Lumbricidae. Actually, some spermathecal and ovarian characters, as well as several of somatic systems, did seem to be equally definitive of seven families comprising a group called the Lumbricoidea (Gates, 1976. Megadrilogica 2 (12): 1).

LUTODRILIDAE McMahan, 1976

This, the third and most recently named nearctic, lumbricoid family, comprises one genus, *Lutodrilus* McMahan, 1976 and its single species, *L. multivesiculatus* McMahan, 1976. The latter was recorded from four south eastern parishes of Louisiana between the Mississippi and Pearl Rivers. Its author seemingly did not consider possibility of any relationship with "*Drilocrius* sp." that Wurtz & Roback (1955) found in Escambia County of the westernmost portion of the Florida panhandle. Perhaps because the Escambia worms had disappeared from the Philadelphia Academy of Science and so could not be examined for any real comparison. Whatever may have been involved, the Escambia form is unlikely to have been of the mentioned genus. Possibly associated with the *Drilocrius* mystery, is the "*Criodrilus* or a related genus" of the Mississippi River that Eisen mentioned as long ago as 1872, without ever providing any further information about the worm or the place from which it had been obtained and how.

McMahan's species, even more than the African megascolecoid *Agastrodrilus multivesiculatus* Omodeo & Vaillaund, 1967, requires consideration with reference the "classical" phylogeny.

The "classical" ancestor of all megadriles (if not also of all other oligochaetes) supposedly had an octogonadal battery comprising four testes, one pair in each of x and xi, also four ovaries, one pair in each of xii and xiii. From that ancestral condition, gonadal batteries of all then-known oligochaetes were derived: 1) By elimination of any one or two pairs of gonads from the ancestral series. 2) By variously shifting gonads of the originnal octet from their previous metameres into other segments. Although probably never so indicated, the sex of the original gonads was assumed to have been finally determined and so as to be irreversible.

The African *A. multivesiculatus* has nine pairs of testes, in segments x-xviii, seven pairs additional to the ancestral form. *L. multivesiculatus* ten pairs of testes, in xii-xxi. The ovaries are but one pair, in xxii of the African and in xxiii of the American. *L. multivesiculatus* now appears to be unique among all oligochaetes, not only by the maximal number of testes (20) but even more by the location of all of its gonads behind the male segments of the supposed ancestral series.

Fifty or more years ago, the author learned that some morphs of the polymorphic, eastern Asiatic *Pheretima anomala* Michaelsen, 1907, had gonads in each of segments v-xiii or xiv, usually associated with gonoducal funnels. Only those *anomala* gonads in x and xi (exceptionally in xii) ever produced any sperm, those of v-ix always remaining juvenile. Had they matured, they almost certainly would have produced sperm, as oligochaetes seem to develop according to a rule that is without exception, *e.g.*, that male gonads must always be anterior to the female. Although hermaphroditic gonads containing both developing sperm and ova are known, such gonads have been reported only between purely testes and purely ovaries of a series.

The author also has learned that the sex of gonads is not unalterably determined. *Dendrobaena octaedra* (Savigny, 1826) probably is holandric, with testes in x-xi normally. Yet in some parthenogenetic morphs (Gates, 1974a), every gonad in segments x-xi now is ovarian. Also noteworthy is the fact that the gonads in xii-xiii of *L. multivesiculatus* as well as of the African counterpart, no longer are ovaries but testes and removed as far as possible from the ovaries. The author is tempted to think that the ancestral oligochaete series may have had many more than four pairs of gonads. Perhaps with ability to develop in any of segments v-xxiii.

L. multivesiculatus has been characterized as "aquatic". Like all sparganophilids as well as species of the microchaetid genus, *Glyphidrilus,* it seems to live only in water-covered mud. For such habitats, limicolous (mud-dwellers) seems to convey information more precisely and so to be scientifically preferable.

SPARGANOPHILIDAE

As a subfamily, this taxon was for a time in the Glossoscolecidae but relationships now seem (Gates, 1974c: 2 and 1976: 1) to be closer to the lumbricoid Hormogastridae, Komarekionidae, Lumbricinae and Lutodrilidae. Perhaps even to the Japanese Biwadrilidae, if ovaries of the latter prove to be lumbricoid. Although the first-named nearctic, megadrile family, it still is monogeneric. Its genus, *Sparganophilus,* though always regarded as North American, has a generotype known as yet only from England (and perhaps France?). That may have influenced Omodeo (1963: 149) to assume that sparganophilids migrated to Europe by the same hypothetical land-bridge that supposedly enabled *Lumbricus terrestris* to reach, some 38-50 million years ago, North America, where it survived the most recent glacial epoch. A more plausible view is that sparganophilids were taken to England since 1500 A.D. and unwittingly by man. Unfortunately, actual records of transport of any sparganophilid never have been found. However, presence of at least two species in aquaria and other artificial conditions such as the Lily House of the Kew Gardens (Reynolds, 1980: 193) does serve as proof of human transportation. Aquatic plants certainly must have been carried around frequently as adult plants rather than as seeds. Earthworms them-selves or at least as small hatchlings, if not also in cocoons, could have been easily moved about concealed in the mud around roots of live plants. The species and some indication of their distribution as recently recorded by Reynolds (1980) is as follows:

Sparganophilus eiseni, nearly fifty states and provinces of the U.S. and Canada. Guatemala, Mexico and England.[16]
Sp. elongatus, England.
Sp. gatesi, Florida (1 site).
Sp. helenae, (North Carolina, 1 site).
Sp. kristinae, (North Carolina, 1 site).
Sp. komareki, (Georgia, 1 site).
Sp. meansi, (Mississippi, 1 site).
Sp. pearsei, (Florida, Georgia, North Carolina, Virginia).
Sp. smithi, (California, 1 site).
Sp. sonomae, (California, 1 site, Oregon, 1 site).
Sp. tamesis, (England, 2 sites. France, 1 site.)
Sp. tennesseensis, (Florida, North Carolina, Tennessee).
Sp. wilmae, (Florida, 1 site).

SUPERFAMILY MEGASCOLECOIDEA

This taxon is the classical Megascolecidae with its subfamilies raised to family rank, plus the African Eudrilidae. All are distinguished from families of the two preceding taxa by their ovaries which are fan-shaped to rosette-shaped, ending distally in several egg-strings.

Each family, even the Eudrilidae, is now represented in the United States.

ACANTHODRILIDAE

For an entire century, one group of genera has been recognized under the acanthodrile name, at subfamily or family level. The fan-shaped ovaries, with several egg strings, enable inclusion of the group as a whole in a superfamily, the Megascolecoidea. Distinction therein, at least from three of the four other families, especially from the two other families with tubular prostates of ectodermal origin, now is by somatic characters. Nevertheless, this family still is one of systematic convenience only (Gates, 1972a: 33). Much greater knowledge of acanthodrile somatic anatomy is needed for a revision that the distribution now seems to require: Australia, Tasmania, New Caledonia, New Zealand, United States, Mexico, Central America, southern South America, South Africa, Madagascar, Ceylon, India, Burma.

Two genera, next to be considered, are solely North American. Indeed, so much so that either is unknown elsewhere, even by a single anthropochore. The third genus, represented on this continent by widely distributed anthropochores, certainly is not North American. The fourth genus, *Pontodrilus,* probably has not been suspected hitherto of being American, though such a possibility may have to be considered in the future.

[16]*S. eiseni* has been recorded from Alabama (7 counties), Arkansas (2), Connecticut (1), Florida (13), Georgia (6), Illinois (2), Indiana (19), Iowa (2), Kentucky (1), Louisiana (3), Maryland (1), Massachusetts (1), Michigan (6), Mississippi (6), Missouri (1), New Jersey (1), New York (7), North Carolina (8), Oklahoma (2), Ohio (12), Pennsylvania (3), South Carolina (1), Tennessee (13), Texas (1), Virginia (1), Wisconsin (1). Ontario (8). (Each of the single county records is also for a single site only. English records are of 1 site though possibly of a double, American origin was suggested.) The central American worms originally were thought to be of other species. Their synonymization perhaps should be confirmed.) Brinkhurst (1971) thought *eiseni* is a synonym of *tamesis* which was unacceptable to Reynolds (1980: 199).

Argilophilus Eisen, 1893

This endemic genus is confined to a narrow, Pacific coastal belt, extending from the San Joaquin Valley of northern California through Oregon and Washington almost to the Canadian border. Until recently, its 19 species were in the Australasian genus *Plutellus* that is thought by some to be "a close relative" (Sims, 1980: 119). Indeed, a recent redefinition of *Argilophilus* (Gates, 1977b: 55 and 58) left one California species, *P. kincaidi* Altman, 1956, in *Plutellus* where it presumably does not belong.

The literature has occasional references to unnamed and undescribed worms that may belong to this genus. Additionally needed also is information about infraspecific variation as distinct from individual variation, of each species. Lamellae, supposedly calciferous, seemingly are developing in several ways within some portion of the esophagous in segments, ix-xvi. Continuation of the processes, seemingly under way, probably will not eventuate usually in extramural glands like those of *P. kinkaidi* but the end result may not always be exactly the same as in some diplocardias such as *D. mississippiensis*. Calciferous lamellae appear to be completely lacking in other species of *Agrilophilus*.

Challenging attention is the problem posed by the geographical separation from each other of *Argilophilus* and the other acanthodrilid North American genus now to be considered.

Diplocardia Garman, 1888

This genus survived the last glaciation in a coastal refugium below the Appalachians, perhaps extending from Virginia across the Mississippi into Texas and Mexico, perhaps also into Arkansas and Oklahoma. Presence in other states probably is due to unwitting transportation by man since 1500 A.D. Nearly forty species were mantioned in the latest review (Gates, 1977a) of the genus. Unfortunately each is inadequately known and perhaps even improperly characterized in part. Joyner (1960) did not even attempt to study his Indiana material because of the "unresolved taxonomy and the inherent difficulties involved in identifying diplocardian species".

Some of those difficulties are provided by diplocardian variation in characters known to be invariable in other megadrile species, genera or even in groups of genera. Also, perhaps in some instances by an unrecognized parthenogenesis which does allow drastic changes (Gates, 1974a: 45-50) in the genitalia on which too great systematic importance long was allowed in megadrile classifications. Some authors identified subsequent material in spite of differences from the original description and, more importantly, without listing those differences. As one result, Gates (1977a: 2) had unresolved doubts about all published identifications of the generotype, *D. communis*. Even including those of the taxons author, Garman. Indeed, Eisen (1900: 190) suspected that the original material of the generotype may have included "two distinct species". That problem still awaits solution, as well as do others too numerous to mention here. Much data as to individual and geographical variation must be accumulated, more especially throughout the southern refugium.

Locations of markings, pores, etc., with reference to the circumference and to the anteroposterior axis are systematically useful characters, in all genera. However, they have not always been stated as precisely as is needed. The megadrile body is marked off into segmental units externally by what are called intersegmental furrows. They are, strictly speaking, not furrows at all as no trace of any grooving is recognizable even in microtome sections. Each furrow, though an almost geometrical line, usually is quite recognizable. By definition the "furrow" is that level where the epidermis is the thinnest, as can easily be recognized in microtome sections. That circumferential line often is at the bottom, especially of strongly contracted material, of a circumferential groove that can only be defined as the more or less depressed neighboring margins of two adjacent segments. Minute spermathecal pores often can be seen to be exactly on an intersegmental furrow. A reference in a species definition to something as "at or close to the intersegmental furrow" may have two different meanings: 1) exact determination was not made (or was impossible). 2) In one definition it meant, at the intersegmental furrow in one subspecies, close to it but actually behind it in the other subspecies.

Ten species, at least, have calciferous lamellae in segments xiv-xv. The lamellae are united mesially in some of those species but in others they are not. Are other somatic characters associated only with presence of those lamellae in xiv-xv? If so, they may be taxonomically interesting and systematically important. An eleventh species *(D. bivesiculata)* has the lamellae in xv-xvi.

An unusual external abnormality was wrongly recorded (Gates, 1977c: 70, Fig. 1) as being on a species of *Diplocardia*. For the correct data see p. 23 above for the Glossoscolecid that really was figured.

Microscolex Rosa, 1887

Microscolex dubius (Fletcher, 1887)

North American Records

1893 *Deltania elegans,* Eisen. Zoe 4: 251 (California.)

1896 *Deltania elegans,* Eisen Mem. California Acad. Sci. 2: 33. (Vicinity of San Francisco, Berkeley, Santa Rosa, Mt. Diablo, California.)

1900 *Microscolex elegans* + *M. carolinae,* Eisen. Proe. California Acad. Sci. (Zool.) 2: 153 and 154 (Santa Barbara, California and uplands near Raleigh, North Carolina.)

1942 *Microscolex dubius,* Gates. Amer. Midl. Nat. 27(1): 88. (North American records.)

1947 *Microscolex dubius,* Macnab & McKey-Fender. Northwest Sci. 21: 71. (Greenhouses, Dayton, Oregon.)

1954 *Microscolex dubius,* Gates. Bull Mus. Comp. Zool. Harvard 111(6): 243. (Rushton, Louisiana.)

1962 *Microscolex dubius,* Gates. Proc. California Acad. Sci. (4), 31(8): 224. (Reproduction probably parthenogenetic.) Proc. Louisiana Acad. Sci. 25: 8. (Louisiana, four parishes. Florence, South Carolina.)

1965 *Microscolex dubius,* Gates. Proc. Louisiana Acad. Sci. 28: 20. (Additional parishes in Louisiana to total 11. Some of those worms reached an unusual size of 117 by 8 mm. Knoxville, Tennessee, Charles County, Maryland. Greenhouses, District of Columbia.)

1967 *Microscolex dubius,* Gates. Great Basin Nat. 27(3): 143. San Diego County, California. Maricopa County, Arizona.)

Material examined: **CALIFORNIA.** RIVERSIDE CO. Fuller Mill Creek on San Jacinto Mt., 21 Apr 69, 0-0-12 (TF-583), E. V. Komarek, Sr. **GEORGIA.** CLARKE CO., Athens, Sandy Creek area, in or under logs in damp forested area, 19 Apr 50,0-0-6 ("like the Fort Davis worms, large, to 70 by 5 mm"), D E. Beck. HALL CO. Clermont, 16 Apr 68 0-0-1, V. B. & W. W. Baker. UNION CO. Suchus, Grizzles store on Route 60, by drainage ditch

on roadside, 28 Apr 67, 0-0-1, W. W. Baker. **NORTH CAROLINA.** DURHAM CO. 1.5 miles west of Durham City limits on Cornwallis Road, 29 Feb 72, 0-0-1 (RLC-136), R. L. Crawford & P. E. Jinright. ORANGE CO. 2.7 miles west of county line on Cornwallis Road, 29 Feb 72, 0-0-1 (RLC-137), R. L. Crawford & P. E. Jinright. **TEXAS.** COMANCHE CO. Comanche, 3 miles west on Route 67, 18 Apr 68, 0-0-2, Ottys Sanders. JEFF DAVIS CO. Fort Davis on bank of Limpia Creek, 13 Mar 68, 0-0-5, 0. Sanders. SOMERVELL CO. Glen Rose, under rotten logs in water of gully from Patuxit River, 13 Mar 66, 0-0-7, O. Sanders. UVALDE CO. Indian Creek Cave, February 1964, 0-0-1, Bill Russell *per* J. Reddell. **VIRGINIA.** CHARLOTTE CO., Charlottesville, under logs and rocks, 26 Apr 56, 0-0-2, D E. Beck.

Interceptions: **MEXICO.** From 5 pounds of earth with unidentified plants, arriving at Nogales, 5 Apr 61, 0-0-1. From earth with clump of violets in baggage on auto arriving at El Paso, 1 Mar 62, (1?)-0-4. **ITALY.** From earth around roots of potted *Jasminium* sp. in baggage on S/S Independence, arriving at New York, 2 May 51, 0-0-8. **SOUTH AFRICA.** From earth with begonia plant in baggage on S/S African Endeavor arriving at New York, 2 May 54, 0-0-1.

Mixroscolex dubius is a "species" known only from athecal and almost certainly parthenogenetic morphs. Whether an amphimictic population is still in existence and if so where, and especially, the size of its spermathecal battery still remain to be learned. Meanwhile, there is much of interest to be learned from those morphs which can easily be secured at appropriate sites and locations. For instance, are the gonads of x-xi becoming ovaries in some of the morphs? Such a feminization process for earthworms has been reported only in *Dendrobaena octaedra* (Gates, 1974b). A more common method of feminization in megadriles is by deletion of the testes *in toto.*

Although this species is as yet uncollected in Florida, its presence there is anticipated because of its achievement of domicile in Georgia as well as in Texas and Mexico.

Microscolex phosphoreus (Dugès, 1837)

North American records

1887 Phosphorescent earthworms (?), Atkinson. J. Elisha Mitchell Soc. 4:89-91. Amer. Nat. 21: 773-774.

1893 *Deltania troyeri* + *D. benhami,* Eisen. Zoe. 4: 251 and 252.

1894 *Deltania troyeri* + *D. benhami,* Eisen. Mem. California Acad. Sci. 2: 33 and 37. (California, San Francisco, Golden Gates Park. Alameda County, Lake Chalot and San Leandro.)

1896 *Microscolex hempeli,* Smith. Bull. Illinois St. Lab. Nat. Hist. 4: 407. (Florida, Gadsden County, Quincy.)

1900 *Microscolex carolinae* + *M. parvus* + *M. parvus* var. *carolinianus* + *M. troyeri,* Eisen. Proc. California Acad. Sci. Zool. 2: 154, 156, 159. (Coulterville, Redding, Santa Barbara, Santa Rosa, California. Ensenada de Todos Santos, Sierra Laguna, Baja California. Orizaba, Mexico. Raleigh, North Carolina.)

1914 "Luminous earthworms", McDermott & Barber. Proc. Biol. Soc. Washington 27: 148. (District of Columbia and Virginia.)

1942 *Microscolex phosphoreux,* Gates. Amer. Mid. Nat. 27(3): 88. (North American records.)

1954 *Microscolex phosphoreus,* Gates. Bull. Mus. Comp. Zool. Harvard, 111(6): 243. (New Orleans. Greenhouse, Bangor, Maine.)

1960 *Microscolex phosphoreus,* Harman. Thesis, Univ. Illinois, p. 71. (Distribution in central Illinois, musculature.)

1962 *Microscolex phosphoreux,* Gates. Proc. California Acad. Sci. (31) 8: 224. (Reproduction probably parthenogenetic.)

1963 *Microscolex phosphoreus,* Gates. Proc. Biol. Soc. Washington 76: 11. (Greenhouses at Bangor, Maine and Devil's Lake, North Dakota.)

1967 *Microscolex phosphoreus,* Gates. Great Basin Nat. 27(3): 143. (Damaged specimens from Arizona.)

Material examined: **CALIFORNIA.** MARIN CO. Tamaalpais station, under rocks, 1 Mar 1900, (?)-(?)-42, G. Eisen. (Juvenile and aclitellates probably were of the same species as the identified clitellates. GEG) SAN FRANCISCO CO., San Francisco, earthworm culture beds of Salvatore Billeci, fall of 1967, 0-0-20 and 0-0-15, S. Billeci. **FLORIDA.** LEON CO., pitfall in corn field, Tall Timbers Research Station, 17-23 Feb 70, 0-0-1, D. L. Harris. **TEXAS.** MENARD CO., Menard, Enco station 17 Apr 66, 0-0-3, O. Sanders. **FRANCE.** La Seyne, Var, in leaf mould around tree stump, 15 Sep 24, 0-0-1, G. E. Hutchinson *per* G. E. Pickford. **ITALY.** Lucrina, 24 Jan 26, 0-0-3. Porto d'Ischia, 24 Oct 25, 0-0-8 and 0-0-1. Messina, 14 Nov 25, 0-0-1. G. E. Hutchinson *per* G. E. Pickford.

Interceptions: **MEXICO.** From 2 1/2 pounds of earth with plants arriving at S. F. bridge, El Paso, 11 Mar 56, 0-0-1. From 3 pounds of earth with amaryllis bulbs in baggage on auto arriving at Nogales, 6 Feb 61, 0-0-1. From 5 pounds of earth with unidentified plants in baggage on auto arriving at Nogales, 5 Apr 61, 0-0-1. From earth with lemon grass plant, *Cymbopogon* sp., in baggage on auto arriving at Nogales, 6 May 61, 0-0-1. **ITALY.** From earth with *Dianthus* sp., in baggage on S/S Saturnia arriving at New York, 11 Dec 49, 0-0-3. From earth with unidentified plants in baggage on S/S La Guardia, arriving at New York, 15 Dec 49, 0-1-2. From earth with carnation plants, in baggage on S/S Conte Biancano, arriving a New York, 19 Mar 50, 0-1-3. From earth with strawberry and rosemary plants in baggage on S/S Atlantic, arriving at New York, 22 Mar 50, 0-0-3. From grape vines in baggage on S/S Vulcania, arriving at New York, 10 Oct 50, 0-0-1. From earth with artichoke plants, in baggage on Plane arriving at New York, 11 Oct 50, 0-1-0. From earth with unidentified plant in baggage on S/S Vulcania, arriving at New York, 10 Nov 50, 0-0-1. From earth with plants of *Ribes* sp. in passenger's baggage on plane, arriving at New York, 10 Feb 58, 0-0-1. From earth with carnation, in passenger's baggage on S/S Independence, arriving at New York, 21 Mar 1956, 0-0-1. From earth with 3 unidentified plants in baggage on plane arriving at Boston, 1 Dec 63, 0-0-1. From one quarter pound of earth with an unidentified plant in baggage on Italian plane AZ608, arriving at Boston, 23 Jan 71, 0-0-1. From one half pound of earth with four plants of cactaceae in baggage on plane, arriving at Boston, 13 Oct 71, 0-0-3 and some fragments. **YUGOSLAVIA.** From earth with 12 grape and fig cuttings in baggage on S/S Uakegonija, arriving at New York, 10 Feb 61, 0-1-3. **GREECE.** From earth with plants in baggage on S/S Olympia, arriving at New York, 5 Oct 55, 0-0-2. **ISRAEL.** From earth in cargo in plane arriving at New York, 3 Mar 50, (9?)-0-1. **JAPAN.** From earth around roots of *Chaenomeles* sp., in baggage on plane arriving at Honolulu, 23 Jan 57, 0-0-1.

External characteristics: Size, 10-25 by 1-1+ mm (strongly contracted). Segments, 36, 45, 46, 56, 59, 63, 64 (2), 65, 66 (4*),[17] 67,

[17]Each asterisk indicates that one of the specimens counted in the parenthesis had in its larger-than-usual anal region two pairs of nephropores. Associated therewith occasionally was a slight, pore-like but imperforate depression at mD. Additionally but rarely, a short rudimentary furrow (intersegmental?) was present. Was a morphallactic delimitation of a new segment within an old metamere under way, after a posterior amputation? Many of the worms of 72 or fewer segments, were suspected of being old posterior amputees.

69, 70 (3*), 71 (7), 72 (8*), 73 (6), 74 (3), 75 (3), 76 (5), 77 (3), 81 (2), 82 (12), 83 (20), 84 (14), 85 (4), 86 (13), 87 (12), 88 (3), 90 (4). Secondary annulation, none. Color, white. Prostomium, epilobous, tongue open (51). Anus, terminal, a vertical slit. Setae, present from ii, *d* setae in dorsum from ii, widely paired. *AB* ca. = or < *CD*, *AA* < *BC*, *DD* < 1/2C. Dorsal pores usually unrecognizable throughout most of the body and seemingly lacking, occasionally obviously present and demonstrated by protrusion therefrom of a cord of coelomic coagulum, at 17/18-34/35 (1 specimen) or at only a few levels behind the clitellum (several specimens). Nephropores, sites obvious, in a single rank on each side of body.

Clitellum, annular, reddish brown to brownish, in xiii-xvii (75) but absent ventrally in xvii and frequently in xiii also, occasionally not reaching 12/13 and/or 17/18. Spermathecal pores, at or just lateral to *A* and at 8/9. Female pores, paired, at or slightly median to *A* and about halfway from 13/14 to eq/xiv. Male and prostatic pores, unrecognized even under highest power of a binocular microscope, though the ventral setae of xvii sometimes could be seen protruding from the epidermix independently. Genital markings, circular to shortly elliptical and then transversely placed, each with a translucent central area. Located as follows: Postsetal: in *AB*/x (4), *AB*/xi (49), median in xi (7), xii (24), xvi (10), xvii (5), Presetal, median in xvi (1), xvii (5), One Mexican worm had a presetal marking on the right side only in *AB*/xi. Genital tumescences, markedly protuberant, closely paired, without central translucence, oval in outline with pointed ends posteriorly, presetal in an elongates anterior portion of their segment, in xviii (17), ix (7), viii-ix (4), ix, left x (1), Lix-x (1).

Internal anatomy: Septa, 7/8-10/11 at least are slightly strengthened. Pigment, none visible in the body wall. A mid-dorsal muscle band such as usually is associated with the dorsal pores of megadriles, was totally unrecognizable throughout each speciment. Pharyngeal glands, extending through vi, vii or even viii. Esophagus: widened, bead-shaped and superficially with a rather gizzard-like appearance in v but there its wall is only a little thicker than in vi and lacks the sheen indicative of special muscularity. In x-xiii or xiv, slightly widened and moniliform, with very low, non-lamelliform longitudinal ridges or with low pavement-block like areas marked off. A more conspicuous ridge at mV (10) sometimes may even be doubled. Intestinal origin, in xvi (36). Typhlosole, none but the gut roof at mD has a low, irregularly zig-zagged, slight thickening, beginning in region of xxiv and becoming unrecognizable by the 38th (of 71), 39th (of 73), 41st (of 75), 54th (of 65) segments.

Dorsal blood vessel, single, recognizable anteriorly nearly to the brain, probably complete. Supra-esophageal, on the gut in ix-xii. Extra-esophageals, uniting at mV on gut in vii, in xiii turning off or bifurcating to continue on the parietes in *BC* and posteriorly at least through xviii. Hearts, lateral in ix, probably latero-esophageal in x-xii though no blood was seen in supposed connectives to the dorsal trunk, last pair in xii (36).

Nephridia, vesiculate, bladders ocarina-shaped, pointed end mesially, the funnel-shaped floor narrowing toward the parietes, passes into an obvious gap in the musculature on each side of the body.

Gonads, present in x-xi (36), often are compact discs of a nearly oblong shape (rather than the normal fan-shape of testes), terminating distally in one to three digitiform lobes which are sometimes marked off into more or less moniliform regions, each of which is about the size of a mature ovum! Gonoducal funnels of x-xi, often smaller than the female funnels, their ducts lack an epididymis but pass posteriorly on the parietes and into the musculature of the body wall immediately behind the prostatic ducts. The gonoducts of a side may be united or they may merely criss-cross over each other irregularly. Seminal vesicles, in xi-xii, often only thin-walled vesicles containing corpuscles sparsely scattered in a watery fluid, sometimes smaller than to only slightly larger than the ovisacs. Prostates, small, passing slightly into xviii or confined to xvii and then either sigmoid or straight, in the latter case reaching only to *C* or to the nephridial gap. Their ducts, slender, usually with muscular sheen, slightly longer than penisetal follicles or obviously even longer than their glands (once), entering parietes on lateral face of the *b* follicles. Penisetal follicles, obviously passing into parietes separately, a common muscle strand from *a* and *b* follicles of a side seemingly inserted well laterally on the body wall together with 17/18. Reserve penial setae, one or two per follicle, yellow.

Spermsthecae, small, subesophageal, bidiverticulate (36) except as otherwise indicated below, passing into parietes at *A* gap. Their ducts, shorter than the ampullae, diverticula shorter than the main axis, each with a stalk about as long as the ellipsoidal to ovoidal seminal chamber, uniting to open through the anterior face of a duct near the parietes. Ovaries, more nearly oblong than fan-shaped, with few egg strings, usually only four. Ovisacs, small, lobed, (16). GM glands, none.

Reproduction

Spermatozoal iridescence was lacking on gonoducal funnels of x-xi (30 specimens). Seminal chambers of spermathecal diverticula usually were empty and always lacked spermatozoal iridescence. No spermatophores were found. Clitellar tumescence was maximal on dissected specimens. The male sterility which is thus indicated requires reproduction to be parthenogenetic. Parthenogenesis having been found in species of Glossoscolecidae, Lumbricidae, Megascolecidae and Ocnerodrilidae, is now known to be not uncommon or rare in earthworms. Male sterility has been suspected in a few species of *Microscolex, Plutellus* and *Diplocardia* for some time, but now for the first time, advanced stages of resultant morphological changes are recorded for an acanthodrilid species. Feminization of the male gonads had already been recorded (Gates, 1974a) for a lumbricid species, *Dendrobaena octaedra.*

Parthenogenetic Polymorphism

Just how much anatomical modification and degradation has taken place in *M. phosphoreus* since reproduction became uniparental is unknown, because a definitely amphimictic population has not been recognized. Thus, for instance, a pair of spermathecae, as well as a pair of prostates could have been lost before or after acquisition of the parthenogenetic habit. Did the ancestral amphimictic population have genital markings in a definite pattern and perhaps associated with some definite kind of gland. Most of the polymorphism now recorded is unrecognizable externally. Greater diversity might previously have been recorded were not the dissection of such small animals so tedious.

Life History Notes

Cocoons are 5+ mm long, (not including the appendages, but if they are included up to 8+ mm long. Diameter at the middle, 2+ mm. One appendage is much slenderer than the other, almost ending in a point or wrinkled backwards on itself (and thus appearing much shorter). The thicker and actually shorter appendage has a rather spatula-like tip with a finely jagged edge terminally.

Abnormality

No. 1. An ovary is present on the right side of xii. No. 2 The gonad on the left side of xii probably is an ovary. No. 3. The single diverticulum of each spermatheca is slightly bifid distally and

opens into the side of the duct rather than its anterior face (Tamalpais). No. 4. Left spermatheca with a single diverticulum joining duct normally but having two equisized seminal chambers (Mexico). No. 5. One spermathecal diverticulum bifid distally (Tamalpais). No. 6. One spermatheca unidiverticulate (Tamalpais). No. 7. Right spermatheca and right tumescences of viii-ix lacking. No. 8. Right male porophore and right tumescence of xviii lacking. Aberrations of specimens 1-8 are of the types that do appear after reproduction has become parthenogenetic. No. 9. Left heart of xii lacking.

Varia

Dorsal pores, in the past, usually were said to be absent in *M. phosphoreus.* The author was unable to satisfy himself as to the existence of an uninterrupted series in the postclitellar portion of the body. Even though a few, widely scattered, extruded cords of coelomic coagulum seemingly suggest that a normal series is present. The anteriormost level at which such a cord demonstrated presence of a pore was 11/12.

Billeci's worms were secured, with an electric probe, from a small plot of rocky, heavy-clay soil with shrubs at the Woodrow Wilson High School in San Francisco.

Pontodrilus Perrier, 1874

This genus comprises gizzardless megadriles that ingest coral fragments, foraminifera, larval pelecypod and gastropod shells. That are circum-globular in the tropics and warmer parts of temperate zones in both hemispheres where they are restricted to salty sea-shores otherwise uninhabited by earthworms. Where and how they originated is unknown. In spite of their wide distribution, no instances or means of transportation are known. Few if any, megadriles have been studied less.

Little or nothing is known about the methods of reproduction, except of course for North American material that has recently been examined. Differences in the genital system that long ago were thought to require recognition of formae, if not also of species, may have been of kinds that now are known to appear after reproduction becomes parthenogenetic.

Pontodrilus bermudensis Beddard, 1891

American Records

1891 *Pontodrilus bermudensis,* Beddard. Ann. Mag. Nat. Hist. (6), 7: 96. (Bermuda.)

1894 *Pontodrilus hesperidum,* Beddard. Proc. Roy. Phys. Soc. 37: 37 (Jamaica.) *"Pontodrilus ? bermudensis"*, Michaelsen, Zool. Jb. Syst. 8: 183. (FLORIDA. Hillsborough County, Hillsborough. Pinellas County, Ozona).

1895 *Pontodrilus michaelseni* Eisen, Mem. California Acad. Sci. 3(2): 73 (Mexico, Guymas.)

1900 *Pontodrilus michaelseni* var. *hortensis* Eisen. Proc. California Acad. Sci. 3 (2): 241. (Loreto, Baja California.)

1910 *Pontodrilus bermudensis,* Michaelsen. Mitt. Mus. Hamburg 27: 84. Also Ann. Mus. Zool. St. Petersburg 15; (Haiti.)

1921 *Pontodrilus bermudensis,* Michaelsen. Ark. Zool. 13(19): 12. (Bahamas.)

1931 *Pontodrilus bermudensis,* Richards. Ecology. 12: 444. (Virginia, Northampton County, Cape Charles.)

1942 *Pontodrilus bermudensis,* Gates. Amer. Midl. Nat. 27(1): 90. (In checklist.)

1943 *Pontodrilus bermudensis,* Gates. Ohio J. Sci. 43(2): 99. (Virgin Islands, St. Croix.)

1954 *Pontodrilus bermudensis,* Gates. Bull. Mus. Comp. Zool. Harvard 111(6): 240. (Florida, Monroe County, Marquesas. Texas, Boca Chica County, Boca Chica.)

1972 *Pontodrilus bermudensis,* Gates. Burmese Earthworms, p. 48. (New state records: Louisiana, Mississippi, Texas. Further information below).

Material examined: **FLORIDA.** FRANKLIN CO. Alligator Harbor, high beach, "supralittoral", 12 Apr 64, 0-15-2, R.E. Tandy. St. George Is., 21 Jun 68, 32-9-29, E. V. Komarek, Sr. Lanark, jetties under rocks, 23 Apr 66, 0-1-13 (JJR-36), J. J. Rudloe. St. George Isl, Sugar Hill, under logs at Harbor, Bay Beach, 23 Mar 72, a number of aclitellates (TF-800). W. W. Baker, D. Harris & V. Tschinkel. MONROE CO. Lower Matecumbe Bay, 3 Jul 68, 78-38-39 (TF-580) and (130?)-15-1, E. V. Komarek, Jr. PALM BEACH CO. Delray Beacy, 3 Sep 68, 0-6-0 + some fragments, E.C. Hopp per D. C. Cook. WAKULLA CO. Alligator Point, upper beach at high tide line, under rocks and wood, 20 Apr 66, 0-4-0, J. J. Rudloe. Also, 11 Jun 66, 0-0-1+ fragments, E. V. Komarek, Jr. & Sr. Wakulla Beach, under sea weed drift along shore, 12 Apr 66, 3-9-18. East Goose Creek, under sea weed drift along shore, 12 Apr 66, 0-15-10, E. V. Komarek, Jr. St. Mark's Wildlife Refuge, 13 Jun 71, 0-92-79 (V-26), C. S. Gidden & V. Vail. **MISSISSIPPI.** JACKSON CO. Bell Fountain Beach near Ocean Springs, 3 inches deep in sand under log a foot from high tide mark, 9 Jul 64, 5-0-1, W. C. Calloway per W. J. Harman. **TEXAS.** NUECES CO. Padre Island, mud flat under 2-3 inches of water between the island and the mainland, 2-0-0, Alan Zapan. Mustang Island, logs on beach, 1930, several specimens, Ottys Sanders. Ransom Island, Redfish Bay, under windrows of plant debris, 10 Jul 54, 4-0-0, "ground water under the spot where the worms were found had a salinity of 34 per mille — almost pure sea water", G. Guntur. **VIRGINIA.** GLOUCESTER CO. Gloucester Point, Vims Beach, Summer 1971 and June 1972, "from area between mid-tide line to about one foot above high tide line", 0-5-0. Robert Diaz *per* M. L. Wass.

CHIPPERTON ISLAND, south Pacific. August 1958, 0-0-1 (macerated), M. H. Sachet. **GUAM.** Pago Bay, above high water under drift of bamboo logs, as well as some in water of interstitial area, 24 Nov 65, 0-13-1, L. Eldredge. **PALMYRA ATOLL.** Under algae thrown up by waves on wet beach, 2-12-10, H. Caspers. **LAYSAN.** 0-0-6, H. Caspers. **FANNIN ISLAND.** South Pacific. Open land of central depression with scattered bunch grass of northwest islet, about one quarter mile from the sea, at or just under the surface beneath coconuts, several juveniles, Wm. A. Newman.

External characteristics: Size, to 83 by 4 mm though many clitellates are much smaller. Segments. 74, 84, 86 (2), all posterior amputees, 86, 87, 90, 93, 94, 95, 96, 99 (2), 100, 103, 105 (5), 106 (3), 107 (6), 108 (4), 109, 110 (4), 111 (2), 112, 113, 114 (2), 115 (3), 119. A posteroterminal region, except on unregenerated posterior amputees, is clearly one of incomplete metameric differentiation in which segments become increasingly shorter posteriorly. Setae, in an anterior portion of the region may be lacking or slightly irregular in their locations. Nephridia no longer are visible through the transparent body wall. Finally, even intersegmental furrows are either indistinct, doubtfully present or even lacking.

Clitellum, in xiii-xvii, ventral margin often not distinct, sometimes apparently saddle-shaped, the clitellar tumescence unrecognizable in *AA* or in a narrow band at mV, setae retained,

intersegmental furrows still faintly indicated. Male pores, minute, each on a very small tubercle located on the lateral wall of a depression lateral to *B. Ventrum* in xviii anteroposteriorly elongated. Genital marking, in *BB,* across 19/20 (113), always distinctly delineated and sometimes markedly protuberant, occasionally with a greyish translucent area on each side just median to *A* (indicative of a paired origin?).

Internal anatomy: Septa, 5/6-12/13 muscular and opaque. Esophagus, wider through xiv-xv, heavily vascularized and with longitudinal rugosities on its inner wall, valvular in xvi. Intestinal origin, in xvii (33+). Last hearts, in xiii (34+), in several specimens those hearts almost did seem to be latero-esophageal(?). Nephridia, discoidal, the surrounding peritoneal cells massively distended (by metabolites?).

Prostatic ducts, 1-2 mm long, much shorter than their thicker glands, with muscular sheen, of variable shape, *e.g.,* a half circle, a J-to a hairpin shape, a C-shape, sometimes with an ental quirk or even with two tiny, u-shaped loops, once shaped almost exactly like a question mark. A longitudinally placed, half-bean-shaped thickening of the body wall protrudes into the coelom on each side of xviii, median to and continuous with a thickening of similar shape which is unrecognizable internally but is protuberant externally.

Spermathecal duct, with a subspheroidal ental portion free in the coelom, not markedly muscular but with a rather large lumen, shorter than the ampulla, ectally adherent by its posterior face to the parietes or buried therein between segmental equators and anterior septa. Diverticulum, shorter than to about as long as the main axis, from anterior face of duct mesially or emerging from the parietes on posterior face of the anterior septum, seemingly with an ellipsoidal seminal chamber that is only slightly thicker than the stalk or almost digitiform but with its lumen gradually widening entally. Ovaries, fan-shaped usually, with numerous egg strings, the longest of which may contain as many as ten ova. Sometimes, discoidal and almost of a rectangular shape, with the mature ova closely crowded in distal half of the gonad but still in five or more rows not separated from each other terminally. The distal apex of one ovary narrowed to a single egg string as in female gonads of the Lumbricoidea.

Reproduction

Spermatozoal iridescence, when present on plicate male funnels, was slight but associated with a similar iridescence of the coagulum within the ental halves of the spermathecal diverticula. As such individuals had copulated, amphimictic reproduction does seem to be possible for them. But if so, is the amphimixis obligatory or optional? Parthenogenesis now seems probable in Guam and U.S. populations.

Mauritius earthworms referred to *P. bermudensis* were believed to be parthenogenetic by Ljungström (1972: 22) who seems to have thought parthenogenesis could explain the systematic difficulties with pontodriles encountered by Michaelsen and Stephenson.

Distribution

P. bermudensis now has been reported from specific sites on coasts of four states, Florida, Mississippi, Texas and Virginia. The species, according to Richards (1931: 444, footnote) had been found commonly in Florida and Georgia by Moore "years ago". Specific localities were not then mentioned nor subsequently for Georgia. It also has been recorded from tropical and subtropical shores all around the world. The male pore region of specimens from the shore of Burma looked exactly like that of Florida forms.

No records of its transportation by man or any other agent have yet been found. The mode of its carriage around the world is unknown. The original home of the genus also is unknown but has not been thought to be in the American hemisphere.

Habitat

Salt water long has been thought to be fatal to earthworms. All pontodriles, as now defined (Gates 1972a: 47), are known only from marine beach areas, where the worms are at least occasionally exposed to some salt water. Reports by several collectors suggest that their worms can tolerate salt content higher than that usual in ordinary sea water. Dr. H. Caspers provided the following information about his Palmyra worms: "In the middle of this island is a hyper-saline lagoon (salinity about 10%), the lagoon is in no direct connection with the sea. Round the lagoon are muddy flats, also with a high content of salt, in part covering the surface. The earthworms here are living in quantity in this bottom which has a high content or organic material."

Material for a study of bioluminescence (Wampler and Jamieson, 1980, Comp. Biochem. Physiol. 66B: 44) obtained at St. Marks Wildlife Refuge, Wakulla Co., Florida, was found, according to Dr. V.A. Vail, (*in litt.,* 31 Jan 82) at high tide level, at the bottom of beach drift (primarily grasses) "approximagely [20-30 cm] thick." The drift "seems to be salty".

Life History Notes

Cocoons, with the St. George lot are 5 mm long excluding the appendages, but may reach 8 mm on inclusion of the appendages. Diameter, at middle 2 + mm thick. The slenderer appendage may almost end in a point or (an empty cocoon) be wrinkled back on itself. The thicker, shorter appendage has a rather spatula-like tip with a finely jagged margin of its free end.

First indication of adolescence was the appearance of a slight swelling in *AB* on each side of xviii, with translucent spots in the epidermis appearing later, one pre- and the other postsetal on each side of the body. Subsequently, a longitudinal ridge gradually becomes protuberant lateral to *B* as the region median thereto becomes depressed and as xviii is anteroposteriorly elongated ventrally. The genital marking becomes recognizable before the clitellum. Male pores were recognized on one juvenile as slight conical protuberances just lateral to apertures of the *b* follicles.

Ingesta

The gut of some specimens was completely filled with white sand grains and, in lesser part, bits of coral. Also present in some specimens were shells of larval gastropods and of two foraminifera (*Amphistegina lessonni* and *Marginopera vertebralis,* identifications by Dr. R. Cifelli). No plant material was found in those instances. Occasionally patches of a gelatinous slime containing sparse, reddish-brown flecks were present. A dark, reddish brown, humus-like material filled gut lumen in the first 16 segments of one worm and the first 56 segment of another, but the remainder of each gut contained only sand grains. Shells of four small bivalves were found in the intestine in one American worm. Some diet for a gizzardless worm!

Regeneration

No. 2. A worm of 103 segments certainly does seem to have a tail regenerate at 60/61. No. 3. The regenerate of another worm at 86/87 is only a large periproct without extenally recognizable indications of any metameric differentiation.

Abnormality

No. 1. Left male terminalia lacking. No. 2. Right male terminalia lacking. In addition to the usual genital marking an exactly similar marking is present at 18/19. No. 3. Left spermatheca of viii, with a doubled ampulla. No. 4. A juvenile had been damaged in the region behind xx and from its right side there had grown a 20-segment tail with a terminal anus.

Varia

The gut of 5 aclitellate worms (TF-800) was of uniform diameter through xvi-xviii and seemingly with an intestinal origin in xix. However, the gut in xiv-xv was very dark because of blood engorgement and the supra-esophageal and extra-esophageal trunks disappeared in xv as usual. Even in those totally relaxed worms, the intestinal origin can only be assumed to be in xvi or xvii.

Precise characterization of the hearts in x-xiii may prove to be of systematic importance. The author never was able to see any blood-filled connection from the hearts to the supra-esophageal trunk, although he several times suspected the presence of empty connectives from the hearts of xiii. "The number of setae varies from 8 to 12 per segment" in *P. bermudensis* from the Gulf of Kutch, India, according to Menon and Sareen (1968).

Parthenogenetic worms from Mauritius, identified by Ljungström (1972: 20) as *P. bermudensis* differ from those described above in the following characteristics; a slightly larger size, a slightly greater number of segments (metameric differentiation seemingly completed in all but one of the specimens), a restriction of the clitellum to xiii or xiv-xvi only, the presence of a sickle-shaped depression which in no way resembles the genital marking of American worms, an intestinal origin in xiv (?GEG), *etc.*

Pontodrilus gracilis Gates, 1943

1942 *Pontodrilus gracilis,* "in press" Gates. Amer. Midl. Nat. 27 (1): 90. (In check-list of North American earthworms.)

1943 *Pontodrilus gracilis,* Gates. Ohio J. Sci. 43(2): 100. (Florida. Lee Co., Fort Myers, edge of Caloosahatchie River.)

1954 *Pontodrilus gracilis,* Gates. Bull. Mus. Comp. Zool. Harvard 111(6): 241. (Florida. Charlotte County, Punta Gorda. According to its collector: "Found in beach sand between tides, putting up castings after the fashion of *Lumbricus*".

Material examined: **FLORIDA.** INDIAN RIVER CO. Sebastian, 19 Apr 19, 0-3-2. VOLUSIA CO. Eldora, Oak Hill, 7 Dec 67, 2-13-6 (TF-519), B. & E. V. Komarek, Sr. Also, 12 Jun 68, 6-11-5 + 5 tails (TF-569) and 22 Jun 68, 6-11-0 (TF-575), W. Wetherill.

External characteristics: Size to 180 by 4 mm. Segments, 111, 129, 140, 142, 146, 147, 148 (2 specimens, both posterior amputees as well as those preceding?), 123, 130, 131 (2, including 1 juvenile), 133 (2, including 1 juvenile), 135, 140, 147, 151 (2), 152, 158, 160. Each of the worms in which amputation is not suspected has at its posterior end a growth region in which metameric differentiation is incomplete. Setae, towards the hind end, the dorsal ranks occasionally become slightly irregular. Nephropores, inconspicuous, whenever sites are recognizable, at *B.*

Spermathecal pores, minute, at 7/8-8/9, very slightly median to *B* to m*AB.* Clitellum, saddle-shaped, reaching down at least to *B* but indistinctly delimited ventrally, indicated by a slight reddish-brown color that may be a preservation artifact and the absence of intersegmental furrows, xiii/eq-xviii/eq (2), xiii-xviii (10).

Internal anatomy: Esophagus, highly vascularized in xiv-xvi or xvii, usually widened, sometimes in part moniliform, so engorged with blood as to seem black, the inner wall smooth. (Is a valve, really lacking?) Gut from xix posteriorly is obviously intestinal, ending in a region of *ca.* 12 segments (a proctodeum?) that is lined with cuticle. Last hearts, in xiii (5).

Holandric, testes fan-shaped. Seminal vesicles, filling coelomic cavities of xi-xii. Male funnels, plicate. Sperm ducts, without any epididymis, joining an ectal portion of the prostatic ducts. Prostates, coiled in xviii. Their ducts, short, straight, or in a single, u-shaped loop just at parietes, lacking muscular sheen, each passing into the lateral face ventrally of a high protuberance into the coelomic cavity. Body wall, obviously thickened over region of the genital markings but no glandular tissue is recognizable therein (the markings with a sucker-like function?). Spermathecae, 3+ mm long, duct much shorter than the ampulla, not slender but without muscular sheen. Diverticulum, from median face of duct at parietes, mostly comprising an ellipsoidal seminal chamber with scarcely any stalk. Ovaries, fan-shaped, with several egg strings, sometimes long enough to reach the dorsum. Each string may have 1, 2 or 3 rows of ova, the number of ova in a row sometimes reaching 50.

Reproduction

Spermatozoal iridescence was recognized in some spermathecal seminal chambers and on some male funnels. Reproduction, in absence of any evidence to the contrary, is assumed to be amphimictic.

Regeneration

Tail regenerates: No. 1, at eq/lxxxiv, of 30+ segments with a terminal anus. Several proximal segments of the substrate may have been reorganized. No. 2, at 127/128, of 5+ segments, with anus still dorsal. No. 3, At 135/136 of 9+ segments with anus terminal.

Metameric differentiation is usually incomplete in a posterior terminal region that can be regarded as: A regenrate. A region in which growth had been inhibited before differentiation had been completed. A growth region in which new segments are being slowly added. The author was unable to decide which alternative was involved in the case of several specimens having a terminal region of as many as nine segments.

Ingesta

Gleaming quartz grains without a single, visible speck of mineral or organic matter, filled the intestine of the Sebastian worms.

Abnormality

No. 1. Right male pore of an aclitellate worm was in xix. An extra segment according to the internalia, had been insercalated on that side, in the region of xiv-xvii. No. 2. Right spermatheca of vii had a second diverticulum from the lateral side of its duct.

Parasites

Tissue present in coelomic cavities of x of some clitellate worms was not a coagulum of the sort often found there in other genera, but rather a mass of discrete, long cords. Teasing those opaque cords apart, revealed in many of them, nearly ellipsoidal bodies

stained much more densely by picric acid than was the matrix in which they were contained. A concavity near one end of each body produced an appearance somewhat like that of a paramecium. Internally, each contained 2, 3, or 4 finely knobbed bodies. Those were dark (not transparent like monocystid nuclei) although a very small central spot did seem to be much lighter.

Varia

An esophageal valve never has been recognized in any of this species. Such a valve does also seem to be lacking in a couple other genera.

No previous record of any casting activity by a pontodrile was found in a recent search through available literature.

Systematics

Differences of this species from *P. bermudensis,* as each is known at present, are mainly quantitative; larger size, more segments, slight differences in location of spermathecal and nephridial (?) pores, point of emergence into the coelom of the growing spermathecal rudiments. The genus, as presently restricted (Gates, 1972a: 47), is in need of a revision which will be possible only after acquisition of much more information about the various forms than is now available. Exact characterization of the hearts, as lateral or as lateroesophageal, may be especially important, because of presence of an esophageal trunk on the gut dorsum.

If *gracilis* proves to be a valid species, will it justify looking for an origin of the genus in this hemisphere?

MEGASCOLECIDAE

This family, long a polyphyletic congeries, recently (Gates, 1972a: 131) was defined by one important character-in-common of all species, though still of the genital system, formerly much over-rated systematically. As so restricted the family extends from Ceylon and India through Burma and Thailand into countries of southeast Asia, China, Korea, Japan, the Philippines, Malaysia, to Australia and New Zealand. One species each of *Lampito* and *Perionyx* as well as a number of the classical *Pheretima,* with the help of man, have attained a wider distribution.

Obviously, the family has no endemics in the American hemisphere. Yet, *Pheretima* may becoming important, perhaps economically as well as otherwise.

Perionyx Perrier, 1872

1960 *Perionyx,* Gates. Bull. Mus. Comp. Zool. Harvard 123 (6): 205-216. (Redefined, primarily by reference to somatic anatomy now known to be more resistant to rapid change than much of the genital system. Also included, a discussion (p. 278) of five kinds of variation that may have "bemused" oligochaetologists into naming "unnatural" species, as well as a statement of the assumptions basic to the author's attempts at various revisions of the classical phylogenetic systematics of the Oligochaeta.)

1972 *Perionyx,* Gates. Burmese Earthworms, p. 138. (Definition as in 1960, except for the omission of two characters, no longer needed, as they are now included in the family definition, p. 231.)

Perionyx eventually became, in classical, megadrile systematics, a polyphyletic congeries that was undefinable morphologically. The author's study of Burmese and Indian endemics (including the generotype), that necessarily involved detailed study of regenerative capacity in several of the species, finally enabled (1960) a redefinition based primarily on more slowly modified, somatic anatomy. The definition of 1972 omitted two, somatic characters no longer need as they then had been incorporated into the family definition.

Several perionyxes have a regenerative capacity, demonstrated experimentally by the author, as well as otherwise, that is unequalled in other megadriles and approximated only by the little-known, European, limnic earthworm, *Criodrilus lacuum* Hoffmeister, 1845.

Perionyx excavatus Perrier, 1872

1972 *Perionyx excavatus,* Gates. Burmese Earthworms, p. 142. (Dominica, West Indies. For locality, see material examined below.)

Material examined: **WEST INDIES.** DOMINICA, Mt. Joy, March, 1949, 0-6-0. Stephen Haweis.

External characteristics: Size, 60-70 by 3 mm. Segments, 106 (probably a posterior amputee, tail end not normal), 106, 118, 126, 132, 139. Two discrete helicometameres were present in the intestinal region of one specimen. First dorsal pore, at 4/5 (4 specimens, but with a pore-like but non-functional marking at 3/4 of two worms), 5/6 (2). Some or all of segments xiii-xvii or xiv-xviii were much lighter in color dorsally than adjacent metameres but no clitellar tumescence was recognizable externally or at parietal incisions.

Internal anatomy: Intestinal origin, apparently in xvi, just behind 15/16 (3 normal specimens). The gut may be very narrow in xviii, presumably as a result of compressions by the prostates. The subneural vessel (1 specimen), was complete, bifurcating under the subpharyngeal ganglion. Nephridial ducts of some postclitellar segments were traceable into the parietes about opposite the thirteenth seta on each side.

Reproduction

A brilliant spermatozoal iridescence characterized all male funnels of each specimen. All spermathecae were empty. Presumably copulation had not been attempted. Amphimixis probable (always?).

Distribution

This is the first record of the species from the American hemisphere and was responsible for the mention of Dominica in a previous publication (Gates, 1972a: 142).

Ingesta

Compost.

Abnormality

Specimen No. 3. Spermathecal pores, at 6/7-7/8. Female pores, in xiii. Male pores, in xvii. Testes and male funnels, in ix-xi. Seminal vesicles, in x-xii. Ovaries, in xii. Prostates, in xvii. Spermathecae, in vii-viii. Anterior abnormalities of this specimen probably arose during cephalic regeneration at 9/10, 10/11 or 11/12. (For numbers 1 and 2, *vide* Gates, 1960. Bull. Mus. Comp. Zool., Havard 123(6): 228.)

No. 4. Spermathecal pores, at 6/7-7/8. Female pores, in xiii, xiv, xv. Male pores, in xviii. Testes and male funnels, in ix-xi. Seminal vesicles, in x-xii. Ovaries and oviducal funnels, in xii-xiv. Spermathecae, in vii-viii. Hearts, large, in vi-xii and right side of xiii, hearts of xii latero-esophageal.

No. 5. Spermathecal pores, at 6/7-8/9. Female pore, in xiv. Male pore, on right side of xviii. Testes and male funnels, in x-xii. Seminal vesicles, in xi-xiii. Ovaries and oviducal funnels, in xiii. Prostate, on right side of xviii. Spermathecae, in vii-ix. Hearts, large, in vi-xii. Abnormalities of this specimen probably arose during cephalic regeneration, possibly at or somewhat in front of 12/13 and during an associated reorganization of proximal substrate segments. One segment is missing internally between xiii and xviii. Regeneration at or behind 17/18 is possible but seems less likely.

Varia

Although two of the specimens were posterior amputees, no tail regeneration was recognizable. The anterior abnormality of three specimens almost certainly resulted from regeneration Yet, none of the other stigmata of regeneration were recognized.

The anterior half of the ental end of the apermathecal duct (normal specimens and several spermatheca of homoeotic worms) is thickened and obviously protuberant externally as a half collar with a knobbed surface. Two unequal and asymmetrical portions are slightly more protuberant than the remainder of the collar. Only two apertures into the duct lumen were found, one for each major protuberance. Seminal chambers were not distinguishable but after copulation, spermatozoal iridescence is expected to demonstrate presence of two, major chambers as well perhaps, as a smaller space for each of the smaller knobs.

Except for the half collar on the spermathecal ducts, and the somewhat smaller segment numbers, no other differences from the Hawaiian specimens (Gates, 1960: 225) were recognized.

Some characters of the digestive system, usually of systematic importance, could not be precisely stated in the species precis (Gates, 1972a: 142). Greater precision was not allowed by the Dominican material.

Pheretima (*sensu* Gates, 1972)

This classical genus, recently (Gates, 1972a: 148) more adequately defined, "is by far the largest of Oligochaeta" (Stephenson, 1930). It was first subdivided (Michaelsen, 1928) into four subgenera. Each of two more, added later (Michaelsen, 1934), was erroneously supposed to be geographically isolated from the others (for comments thereon see Gates, 1972a: 140). Those changes not having been accepted, Sims & Easton (1972) split the classical taxon into several genera. Two of which, *Amynthas* and *Metaphire*, recently (Reynolds, 1978) were reported from the state of Tennessee. Each of their definitions (Diagnoses), as cited by Reynolds, seems unsatisfactory in various ways. Too many of their taxonomic characters are qualified, as by; "rarely" (5 times), "or" (3), "usually" (2), "occasionally" (1), for *Amynthas* and "or" (5), "rarely" (2), "seldom" (1), "as occasionally" (1), "often" (1), "usually" (1), for *Metaphire*. The author believes that any good genus, with a single origin, ought to be able to show it by possession of positive characters without modifying qualifications and exceptions. Indeed, he has shown that an Asiatic Octochaetid genus *Eutyphoeus*, can be so defined (Gates, 1959: 247). Though with a range extending from Tenasserim and the western margin of the Shan Plateau of Burma into the Gangetic Plain and west through the Himalayas beyond Nepal in India.

Some characters of the pheretimoid definitions under consideration are not qualified: 1) "Prostatic glands racemose." Actually that single character uniquely defines the family to which all pheretimoid genera belong. It is better stated as by this author (Gates, 1972a: 131). Prostates, racemose and of mesoblastic origin. 2) "Ovaries paired in xiii." Also definitive of the Megascolecidae, as well as of the entire super family Megascolecoidea. Better stated as, Ovaries, in xiii (pairing understood as the plural is used though only one segment is mentioned), fan-shaped and with numerous egg strings. 3) "Gizzard between septa 7/8 and 9/10." The gizzard develops in segment viii of every pheretimoid species. What happens to septum 8/9 as well as 9/10 (including partial or total abortion, even muscularization) is of minor importance. 4) "Esophageal pouches absent." What may be intended by that character is not understood by the present author. None of the literature that can be consulted locally, as this is being written, states where the structures in question are located. All that has been found is the statement as to their absence in the Tennessee article. Very probably their presence or absence has been recorded for only a very few pheretimas.

One defining character that is not qualified, "Testes holandric rarely proandric or metandric", listed every possible alternative for a *Pheretima*, except of course anandric, which is, obviously, an abnormality and mainly limited to male sterile, parthenogenetic morphs.

Much more worthy of being separated off from the classical *Pheretima* than any species hitherto suggested are those of a group comprising *P. godefroyi* (Michaelsen, 1907), *sedgewicki* (Benham, 1897), *mira* Gates, 1972, *etc.* Each of them is uniquely distinguished (Gates, 1972b), not only from other pheretimoids, but also from all other megadriles, by several genital characters whose systematic importance long has been inadequately appreciated. Indeed, a genus with *sedgewicki* as its type could, insofar as is now known, be defined as follows: Testes, two pairs, in xi-xii. Ovaries, annular and with many egg strings, each gonad along with a gonoducal funnel in a posteriorly directed, conical, ventral, ovarian sac. Intestine, with a single, ventromedian caecum extending forward from region of xxii-xxiii. Hearts, last pair in xii. (Possibly also: Septa, 8/9-9/10, complete.)

Additional systematically important characters may be recognized when other somatic anatomy can be characterized. Even our present, obviously defective knowledge of the vascular system requires deletion of one character in a family definition (the Megascolecidae, as in Gates, 1972a: 313), *e.g.*, the terminal pair of latero-esophageal hearts being behind the "last testis segment". Bahl, who was responsible for our knowledge of the excretory system of several peregrine pheretimoids (but mainly of *P. posthuma*) assumed that the nephridial system in all other species of the classical genus *Pheretima* was the same. Although some, more or less minor differences at least probably do remain to be properly described, the excretory system remains unstudied in all endemic pheretimoids. The only character of that system used in recent revisions is the presence or absence of nephridia on the spermathecae (due to retention of a peritoneal investment as the reproductive organ grew from the body wall into the coelom?). If, as Bahl believed, the excretory system is found to be the same, or with but slight differences, perhaps subgenera instead of discrete genera should be considered, in dividing the classical *Pheretima*.

Fifteen species of *Pheretima* now are domiciled, probably permanently, in the United States. Three species, *P. agrestis, hilgendorfi* and *levis*, having manicate intestinal caeca, almost certainly were brought here directly from Japan.

Systematics

Identification of many parthenogenetic megadrile individuals requires knowledge of normal genitalia of its ancestral, amphimictic population. Determination of such normality from individuals with incompletely or abnormally developed reproductive systems, even when numerous specimens are available, has proved to be more difficult than was anticipated years ago when the author hopefully promised species definitions, he since has learned he cannot provide.

A damaged individual of a Japanese taxon that was believed (Gates, 1973a: 331) to be *Pheretima sieboldi* (Horst, 1893) had a superficial right male pore but a left male pore that definitely was invaginate. In megadrile development, invagination of genital pores, whether male or spermathecal, is a secondary development. Hence the right male pore of the author's *sieboldi* individual was denied further development at an early stage of male-terminalia growth, and actually represents reversion to a long lost ancestral condition. That greater development of the left male terminalia certainly justifies expecting the amphimictic ancestral population to have invaginate male pores. But will those invaginations be slight or small as is definitely species-characteristic of the classical *Pheretima harrietensis* Stephenson, 1925, and *posthuma* (Vaillant, 1868)? Or deep, though still confined within the body wall as in the classical *P. peguana* (Rosa, 1890)? Or, like that much later stage in the same evolutionary development, of a copulatory chamber protruding well into the coelom, as in *P. houlleti* (Perrier, 1872) and many other species?

The latest attempt at revision of the classical *Pheretima* (Sims & Easton, 1972) allows considerable importance to the male terminalia. The right male pore of the *sieboldi* worm would require reference to the proposed genus *Amynthas,* but the left pore would require reference to another genus, *Metaphire.* An intergeneric hybrid is inconceivable as even species hybrids are unknown in megadriles. The author's study of abnormality and regeneration, has shown that considerable difference in structure is possible, between right and left sides, even of cephalic segments, in functional individuals.

The evolutionary development shown by the *posthuma-peguana-houlleti* series is not the only one showing retraction of the male pores. Some Chinese pheretimas show several stages of a quite different mode of withdrawal from the exterior surface. No matter how great the contained space may become, it always remains confined within the body wall because that is the only way it can grow. At greatest development probably regarded as a "copulatory chamber," instead of a parietal invagination, the resultant space should not have the same name as sometimes do smaller coelomic spaces.

Key to species of *Pheretima* now domiciled in the U.S.

1. Athecal, unpigmented, genital markings paired, presetal behind xviii ..... *P. elongata*
   Thecal 2

2. Spermathecal pores, one pair 3
   Spermathecal pores, more than one pair 4

3. Spermathecal pores at 5/6, size of worms small ... *P. minima*
   Spermathecal pores at 7/8, size larger ..... *P. taprobanae*

4. Spermathecal pores, two pairs 5
   Spermathecal pores, more than two pairs 12

5. Spermathecal pores at 5/6-6/7 6
   Spermathecal pores behind 5/6 8

6. Male pores superficial, two GM close to each male porophore 7
   Male pores invaginate, genital markings paired, presetal, behind xviii ..... *P. elongata*

7. Size, 90-113 by 4-6 mm, segments 127-169 ..... *P. loveridgei*
   Size, 14-68 by 2.5-4 mm, Segments, 62-98 ..... *P. morrisi*

8. Spermathecal pores at 6/7-7/8 9
   Spermathecal pores at 7/8-8/9 10

9. Male pores superficial ..... *P. levis*
   Male pores invaginate ..... *P. hilgendorfi*

10. Male pores superficial, GM usually present ..... *P. robusta*
    Male pores invaginate, GM lacking 11

11. Intestinal caeca simple ..... *P. californica*
    Intestinal caeca manicate ..... *P. schmardae*

12. Spermathecal pores three pairs 13
    Spermathecal pores more than three pairs 16

13. Spermathecal pores at 5/6-7/8 14
    Spermathecal pores at 6/7-8/9 15

14. GM when present, a presetal pair in xviii, paired small areas of finely wrinkled epidermis in vii-viii, male pores usually lacking in the U.S. ..... *P. agrestis*
    GM usually present, small circular tubercles, post-setal in xviii and median to male pores ..... *P. hawayana*

15. Male pores superficial ..... *P. hupeiensis*
    Male pores invaginate ..... *P. houlleti*

16. Spermathecal pores four pairs, at 5/6-8/9 17
    Spermathecal pores, five pairs, at 4/5-8/9 ..... *P. bicincta*

17. Spermathecal pores in the dorsum ..... *P. rodericensis*
    Spermathecal pores not in dorsum 18

18. Male pores superficial ..... *P. diffringens*
    Male pores invaginate ..... *P. posthuma*

Pheretima agrestis (Goto & Hatai, 1899)

American records

1939 *Pheretima agrestis,* Howell. J. Exp. Zool. 81: 231. (Maryland. Responses to light.)

1953 *Pheretima* sp., Gates. Bull. Mus. Comp. Zool. Harvard 107: 529. (A small juvenile from a Massachusetts arboretum.) *Pheretima agrestis,* Gates. Breviora, No. 15: 5. (From the same place, Suffolk Co., Massachusetts, 0-0-56. Reproduction by parthenogenesis is "likely.)

1954 *Pheretima agrestis,* Davies. Breviora, No. 26: 10. (Garden, New Jersey, 0-0-2.) Gates, Bull Mus. Comp. Zool. Harvard 111: 224. (Aquarium building, New York City, 0-0-9. Florists nursery, Albany, New York, 0-0-8.)

1958 *Pheretima agrestis,* Gates. Amer. Mus. Nat. Hist. Novitates, No. 1888: 1. (Schenectady, New York, 0-0-1. Greenwich, Connecticut, 0-0-1. Shreveport, Louisiana, 0-0-4. In the U.S. reproduction must be parthegenetic.)

1962 *Pheretima agrestis,* Stebbings. Amer. Mid. Nat. 67: 105. (Crawford County, Missouri.)

1963 *Pheretima agrestis,* Gates, Proc. Biol. Soc. Washington 76: 11. (Greenhouse records.)

1965 *Pheretima agrestis,* Bhatti. Proc. Pennsylvania Acad. Sci. 39: 20. (Pennsylvania, 0-0-14.)

1966 *Pheretima agrestis,* Gates. Proc. Biol. Soc. Washington 79: 245. (Soil under plant benches, greenhouse, Waterville, Maine.)

1969 *Pheretima agrestis,* Tandy. Thesis, Louisiana State Univ., p. 16. (Louisiana, 17 sites in 13 parishes, 0-8-129.)

1977 *Amynthas agrestis,* Reynolds. Megadrilogica 3(2): 53. (Hampshire Co., Massachusetts, 0-0-1.)

1978 *Amynthas agrestis,* Reynolds. Megadrilogica 3(7): 113. (17 sites in 13 counties of Tennessee. New state records for Alabama, Georgia, North Carolina, Oklahoma, and South Carolina, for the localities see, material examined section below.)

Material examined: **ALABAMA.** Dallas County, Selma, 10 Jul 69, 0-4-34 (TC-55), E. V. Komarek Sr. MONTGOMERY CO. Montgomery, 10 Jul 69, 0-2-100 (TC-59), E. V. Komarek, Sr. TUSCALOOSA CO., Old Lock No. 14, area along Black Warrior River, 20 Sep 67, 0-0-1 (TF-266), V. B. & W. W. Baker.) **CONNECTICUT.** FAIRFIELD CO. Greenwich; in compost heap near Saxon-Krueger greenhouses, 26 Aug 57, 0-0-12 and 28 Oct 57, 0-0-10. Beckerley residence at Riversville Road, in and under leaf piles, under logs in woods, 10 Aug 60, 0-129-116. GEG. **FLORIDA.** SUMTER CO., Dade Battlefield Memorial Park, in and around worm-bed back of Superintendent's house, 14 Oct 71, 0-0-1 (RLC-93), R. L. Crawford & P. E. Jinright. **GEORGIA.** CLARK CO. Athens, 1 May 69, 43-0-0 (TF-529B), E. V. Komarek, Sr. **NEW YORK.** NASSAU CO., Sea Cliff, at 231 Littleworth Lane, 0-0-3. (Also a Long Island collection of 26 Sep 58 without other data, 0-0-3.) J.F. Corman *per* G. E. Pickford. **NORTH CAROLINA.** BURKE CO., Morganton, 2.6 miles north, Johns River, 13 Oct 67 (TF-303), V. B. & W. W. Baker. **OKLAHOMA.** MCCURTAIN CO., Idabel, 14 Aug 68, 0-0-2, (TF-454), W. W. Baker. PITT CO. Greenville, residential area, 6 Jul 72, 0-0-2 (H-62), 11 Jun 72, ?-24-5 (H-17), 1-4-1 (H-18), 1-4-0 (H-19B). Bypass at Route 264, 5 Jul 72, 0-0-1 (H-60). Residential area, 6 Jul 72, 0-0-13 (H-61), 12 Jul 72, 0-0-41 (H-78). ECU campus, 11 Jul 72, 0-0-8 (H-74). D. N. Howell. **PENNSYLVANIA.** DELAWARE CO., Swarthmore, Swarthmore Forest, 1962, 0-0-3, H. K. Bhatti. **SOUTH CAROLINA.** DARLINGTON CO., Hartsville, 13 Oct 69, 0-0-26 (TF-646). JASPER CO., Ridgeland, 15 Jul 69, 0-0-1)TF-603A), along with *P. hilgendorfi.* E. V. Komarek, Sr. **WEST VIRGINIA.** SUMMERS CO., Hinton, 10 Sep 68, 0-0-1 (TF-479), W. W. Baker. **JAPAN.** Kuchan, from a second pine forest in the suburbs, 4 Aug 59, 0-0-7. Mt. Yotei, from a bush at foot of the mountain, 5 Aug 59, 1-0-0. Students *per* S. Kobayashi.

External characteristics: Size, to 160 by 8 mm. Segments, 67, 71, 74 (posterior amputees, unregenerated), 90, 91 (2), 92 (2), 93, 94, 95 (6), 96 (7), 97 (19), 98 (10), 99 (12), 100 (21), 101 (27), 102 (31), 103 (30), 104 (19), 105 (8), 106 (14), 107 (2), 108, 110. Color, reddish brown to slate. Prostomium, epilobous, tongue open (all). First dorsal pore, at 12/13 (75), four of those specimens had a tiny mark at mD on 11/12 that looked as if it might be a rudiment or a vestige of a marking though actually non-functional.

Primary male pore, possibly minute but almost certainly is not superficial. On one unilaterally arsenosomphic specimen, a minute pore was at center of a small, circular disc at tip of a marked but rather irregular protuberance. The latter almost certainly must be withdrawn, at least into the body wall, leaving the closed secondary aperture with a finely wrinkled margin that could be characterized as tranversely slit-like. On another similarly defective specimen, no male pore was seen to be on a slenderly conical, 1+ mm long, penis-like protuberance with a glabrous surface. No discoidal marking was visible. The structure obviously must have to be withdrawn but, would the chamber thus formed extend into the coelom, above the body wall level? The secondary aperture might be like that just postulated for the chamber containing a discoidal porophore? Also, were the two worms of the same species, as was believed at first?

Spermathecal pores, minute, superficial, each exactly at level of an intersegmental furrow but at center of a distinct, circular to shortly elliptical, small porophore, the latter is retracted in such a way as to produce an appearance of a larger and transversely slit-like aperture, by folding the two anteroposterior halves together at their middle and along the intersegmental furrow.

The only definite genital markings are postclitellar, presumably one pair in xviii. At best development, they can be characterized as follows; Circular, usually just median to a male porophore. If both of the assumed pair were present, they would be separated from each other mesially by a space about equal to four intersetal intervals. Anteroposterior maximal extent is from slightly behind eq/xviii almost to eq/xvii. (Intersegmental furrow 17/18 unrecognizable in the ventrum.) Presumably, the marking had a presetal origin but grew slightly further posteriorly than anteriorly. A narrow but distinct and raised rim is clearly marked off from the concave and greyish-translucent central area.

Definite preclitellar genital markings always were lacking on American material. However areas of slight epidermal modification often are recognizable in vii and/or viii ventrally. The areas may be unpaired and median or symmetrically paired. Differences from the adjacent epidermis though easily recognized are slight and may be described as a very fine wrinkling, grooving or cross-hatching, occasionally with some slight yellowish browning like that on the clitellar segments after disappearance of all epidermal tumescence.

Internal anatomy: Special longitudinal muscle band at mD, first recognizable from slightly behind 11/12. Pigment, red, in circular muscle layer (only dorsally?). The dorsal typhlosole is represented by a very low and rather irregular ridge at mD even from xvi (vestige or rudiment?) but does not become slightly lamelliform until into xxvii. Even at best preservation, it's height seems to be gradually decreased from somewhere in the region of segments xl to l, becoming completely unrecognizable from the 61st (of 102), 70th (of 102), 72d (of 102), 73d (of 103) segments, respectively. Hearts, of ix on left side only (16), on right side only (15), on both sides (3, in one of which the right heart is abnormally slender in its ventral portion), of x lacking (22).

Prostates, when present may extend through some or all of xvi-xxiii. Their ducts, 2-5 mm long, in a C to U-shape, with ectal limb obviously thicker and with muscular sheen. The male gonoducts join the entalmost portion of the prostatic duct when the latter is present but in its absence attenuate anywhere in the region of xv-xxvi. The spermathecal duct, with muscular sheen but not especially thickened, is shorter than the ampulla. The diverticulum is longer than the main axis and its ellipsoidal seminal chamber may contain a whiteish coagulum. The GM gland (?) is compact and very firm, only very slightly protuberant above the general level of the body wall. No special modification of the parietal tissue was recognized over the preclitellar areas of slight epidermal modification.

Abnormality

No. 2. (Continued from Gates, 1953: 6.) Single female pore at mV in each of xiv, xv. On left side; clitellum was in xv-xvii and spermathecal pores were at 6/7-8/9, epidermal roughenings were

in viii-ix. Internal organs of left side, from the first spermatheca, including intestinal and caecal origins, were one segment behind corresponding organs of the right side. Yet, metamerism of the first thirty segments was normal, at least externally. No. 3. Segment viii was lacking on the left side where spermathecal pores were at 5/6-8/9. Another metameric anomaly involved x-xi or xi-xii. Clitellum of left side one segment in front of its right half, as is the intestinal origin and the caecal origin of the left side. Left heart of xiii, lacking. No. 4. Segment xii, lacking on the right side, so that the clitellum of the left side was one segment anterior to its right half. All organs from the first pair of seminal vesicles, asymmetrical. No. 5. A sixth segment, short and with setae only in the dorsal, left quadrant, probably was cut off from what should have been v. Additionally, a spiral metamerism involved xi-xiii, Clitellum of right side, one segment behind its left half. Posterior two spermathecae lacking on the left side. No. 6. Female pores, at mV in xiv and xv. Left side: Two short, setal segments corresponding to the space occupied by x of the right side. Clitellum, in xv-xvii. Testis sacs, seminal vesicles, last heart, intestinal origin and caecum one segment behind normal position. No. 7. A spiral abnormality involved x-xii but was unrecognizable ventrally where segments were counted. Clitellum was in xiv-xvi on the right side but in xv-xvii on the left side. Female pores, at mV, in xiv and xv. No abnormality in metamerism was recognized in or behind the clitellum. However, septa were inserted on the gut so that left-side organs of xi-xiii are opposite right side organs of xii-xiv.

No. 8. Metamerism abnormal in xiv-xxvi. Female pores, median in two consecutive segments. Left genital organs from first testis sac, one segment behind those on the right side. Right seminal vesicles much smaller than those on the left side. No. 9. Metamerism abnormal from v to the hind end. Two female pores at mV, in different segments. One male pore present, on the right side. Right genital organs from the anterior testis sac, one segment behind those on the left side. No. 10. Segment ix is narrow and lacks setae on the right side. Female pores, at mV, in xiv-xv. Right genital organs from first testis sac, one segment behind those of the left side. No. 11. Metamerism in region of viii-x is abnormal. No. 12. Segment xviii is present on one side only.

Systematics

More than twenty years ago, a group of pheretimoid species arriving at the author's laboratory posed a much more difficult problem to him than specimens of the Chinese species *P. hupeiensis* and material of *P. diffringens* and *hawayana* did to previous American investigators. Indeed a problem still unsolved. Primarily because of the very genital organs by which species in the prevailing earthworm classification (the classical system of Michaelsen, 1900 and Stephenson, 1930) were almost entirely distinguished, identified and defined.

Fortunately somatic organs of unknown function, the manicate intestinal caeca, showed that the Chinese species was not involved and that Japan was more likely to have been the original source. An occasional individual with one or more spermathecae, and/or one or more parts of the male terminalia, enabled tentative recognition of three already-named species. Presumably then, the more common AR morphs (lacking all spermathecae and male terminalia) should be referable to the same three taxa. But which of the three, for any particular AR individual could be determined only by unknown somatic structure. In absence of normally amphimictic individuals, estimation of the amounts of morphological change and especially of degradation, of the retained spermathecae and terminalia of occasional individuals, was very difficult. Pending acquisition of information as to individual variation in important somatic organization as well as for the normally functioning genitalia of an expected amphimitic population, presentation of species definitions (Gates, 1958: 3, etc., was postponed to some future but unknown date. None of the additional material eventually secured, even that which came directly to the author from Japan, was amphimictic and procuring the requisite data as to normal individual variation in somatic organization was much slower than had been anticipated. Until after study of an amphimictic population (if one still exists and can be found), no brief, species characterization can be regarded as finally definitive. A summary of what now can be expected in the parental amphimictic population is called a precis as below.

Repetition of characters already included in the generic definition (Gates, 1972a: 148) is, of course unnecessary. The Japanese species considered below, unless otherwise indicated, along with many other pheretimoids, have the following characters in common: Prostomium, epilobous, tongue open. Female pore, median in xiv. Clitellum, annular, in xiv-xvi. First dorsal pore at 12/13. Pigment, red. Septa, 8/9-9/10 at least in large part aborted (represented only by ventral rudiments). Intestinal origin, in xv. Dorsal intestinal typhlosole, simply lamelliform. Ventral typhlosole, horizontal, narrowly band-shaped. Intestinal caeca, manicate, paired from xxvii, dorsalmost secondary caecum the longest length decreasing ventrally. Last pair of latero-esophageal hearts in xiii, hearts of x lacking. Seminal vesicles in xi-xii.

An unknown number of specimens (perhaps only one?) from unmentioned sources, with invaginate male pores, were referred by Reynolds (1978: 119) to *Amynthas agrestis*, in spite of his defining *Amynthas* (on that same page) as having superficial male pores. His characterization of the male-pore region is "minute and located on an eversible papilla, inside a transverse, slit-like parietal invagination on an elevated porophore in the setal circle of xviii". That characterization with this author's (above), certainly justify a conclusion that male pores of the amphimictic, ancestral population are indeed invaginate. But, still to be determined is the depth of that invagination, and more especially whether restricted to the body wall or reaching more or less conspicuously into the coelom. Previously, this author had felt that the peculiar epidermal condition in segments vi-viii might have resulted from or in some way been associated with deletion of long-stalked coelomic glands. That now seems unlikely as the larger GM gland of each postclitellar marking is of a totally different kind.

Obviously, *agrestis* does not belong in any genus defined as having superficial male pores. The somatic anatomy indicates close relationships with *hilgendorfi* and *levis*, even though male pores of the latter still must be considered to be superficial.

Pheretima bicincta (Perrier, 1875)

North American records

1908 *Pheretima violacea*, Michaelsen. Zool. Jb. Suppl. 11: 15. (St. Thomas, West Indies.)

1937 *Pheretima bicincta*, Gates. Bull. Mus. Comp. Zool. Harvard 80(8): 346. (Description, after examination of types of *violacea*. "Diagnosis". In key to North American species of *Pheretima*, p. 342.)

1942 *Pheretima bicincta*, Gates. Amer. Midl. Nat. 27(1): 91. (In check list of North American earthworms.) Bull. Mus. Comp. Zool. Harvard 89(3): 119. (Description of Burmese specimens. Genital markings not marked out though sites of GM gland pores were recognized. Mature sperm not found but the worms though still clitellate may otherwise have been in a postsexual condition. Original home of the species unknown.)

1958 *Pheretima bicincta*, Gates. Amer. Mus. Nov. No. 1888, p. 31. (In key to North American species of the genus.)

1963 *Pheretima bicincta,* Gates. Proc. Biol. Soc. Washington 76: 12. (Greenhouses, Bangor and Bar Harbor, Maine.)

1972 *Pheretima bicincta,* Gates. Burmese Earthworms, p. 170. (Type locality, supposedly on Mindonoro or Luzon, Philippines. Parthenogenesis suspected. New state record, Florida. For localities see below. Precis.

Material examined: **FLORIDA.** DADE CO., Florida City, 15 Aug 74, 0-0-2 (KO-229), 0-0-3 (KO-230A) and 0-0-5 (KO-230B). Gould's, 15 Aug 74, 0-0-10 (KO-228) E. V. Komarek, Sr. HENDRY CO. Clewiston, 4 Jul 68, 0-0-1 (TF-411), W. W. Baker & P. E. Jinright. **GEORGIA.** THOMAS CO. Thomasville, 1 Jan 71, 0-0-1 (PEJ-1), P. E. Jinright. **HAWAII.** OAHU, Kalihi Valley, 12 Jul 60, 0-1-0, Brenda Bishop *per* Y. Kondo. Laie trail, 30 Mar 63, 0-0-1, Y. Kondo. **PHILIPPINES.** Bayan, Banauee, Ifugao, 20 Jul 69, 0-0-4, W. C. Conklin. **SOUTH CAROLINE ISLANDS.** WERUA ISLAND, Kapingamarangi Atoll, top soil under surface debris, coconut-breadfruit forest, 21 Jul 54, 0-0-1, W. A. Niering.

Interceptions: **MEXICO.** From 2 pounds of earth with a bougainvillea from Guadaljuara, Jalisco, in baggage on auto arriving at Nogales, 18 Nov 61, 0-0-2 From 20 pounds of earth with two plants in baggage on auto arriving at Nogales, 17 Aug 62, 0-0-3. **GERMANY.** From carton of plants (*Dieffenbachia* sp.) in cargo on plane arriving at New York, 23 May 58, 0-2-0. **PHILIPPINES.** From 3 pounds of earth with unidentified plant in a pot arriving at New York, 28 Aug 57, 1 macerated specimen.

External characteristics: Size, to 80 by 3 mm. Segments, 77, 78, 82, 83 (3), 84 (2), 88 (some or all of the preceding posterior amputees?), 90 (5), 91, 92 (2), 93, 94 (2), 96 (2), 97, 98 (2), 99 (3), 100, 101. Segment x is the longest. Color (Florida only) red, in dorsum, recognizable to or almost to the anal segment. Setae, usually visible in each clitellar segment, circles occasionally complete in xiv-xv and usually so in xvi, sample counts; 52/xii, v/ll, vi/12, vii/12, viii/14, xvii/13, xviii/8, 9, xix/13, one seta often present in each male porophore. First dorsal pore, at 12/13, often (Florida specimens), with a bit of coelomic coagulum protruding to the exterior in the pore.

Clitellum, usually reaching 13/14 but never to eq/xvi. Female pores (a pair!) anteromedian to *a* (31). Male porophores (when visible), seemingly of variable size and shape, when largest (and then united with genital markings), slightly dislocating 17/18 and 18/19. Presumed sites of the pores, usually superficial, were sometimes (all of Florida specimens) within slight transverse, equatorial furrows (vestiges of some kind of invagination?). Genital markings usually are unrecognizable, or not certainly distinguishable even though GM glands are present in the coelom but sometimes are (all Florida specimens) markedly protuberant though without bounding furrows, shortly and thickly ellipsoidal, two pairs, one presetal and the other postsetal in xviii, slightly dislocating 17/18 and 18/19, almost meeting at eq/xviii so as to leave no space for male porophores.

Internal anatomy: Pigment, present even when any color is unrecognizable externally, reddish to reddish brown, and associated with the circular muscle layer. Special longitudinal muscle band at mD, present from 11/12 where is no pore yet quite distinct in xi (1 specimen), visible only from 12/13 (other worms).

Intestinal caeca may be confined to their own segment and if so, then are directed dorsally (so as to overlap one another above the dorsal blood vessel) or ventrally. Typhlosole, simply lamelliform, present from the caecal segment (xxii), ending in 51st (of 90), 53d (of 96), 69th (of 84), 71st (of 98) segments, rudimentary behind the 62d, 38th or 47th segment (Hawaiian specimens).

Supra-esophageal trunk, recognizable only in x-xii. Subneural trunk, unrecognized (14+ dissections). Hearts, unaborted dorsal portions of viii passing to the gizzard, of ix lateral and both present (12+), last pair in xii (14+).

Prostates, lacking or medium-sized to large and then extending through some or all of xvi-xx. Their ducts, 3-6 mm long, with muscular sheen, in a U-shaped loop with the ectal limb much thicker and sometimes rather spindle-shaped. GM glands, lacking or present and then often finely acinous. Ovaries, fan-shaped, with several short egg strings. Spermathecae, when present, always small, subesophageal, diverticulum not always shorter than the main axis.

Reproduction

All dissected specimens (including some from Maine and Burma), were male sterile. Accordingly, reproduction must be parthenogenetic.

Parthenogenetic Polymorphism

Athecal and aprostatic morphs, hitherto unknown in this species, have now been found. Genital markings of Florida worms are better developed than any other this author has seen hitherto in this species, but the associated glands are not as well developed. The male pores hitherto were thought to be superficial in *P. bicincta.* Their invagination, if involved in the ancestral amphimictic population, as now seems somewhat likely, will distinguish the species from all other pheretimas having spermathecal pores at 4/5-8/9, and so will be of some systematic importance. An amphimictic population now seems likely to have two pairs of genital markings in xviii, one pair presetal and the other postsetal, but more distinctly delineated than in the Florida worms.

Distribution

India, Penang, Java, the Philippines, Taiwan, Caroline Island, Hawaii, Trinidad, Grenada, St. Thomas (Burma, in earth of a potted plant during the two years, Mexico, from earth with potted plants). *P. bicincta* never again was found in Burma during twenty years of extensive and often repetitive collecting throughout much of the country. The history of the Burma plant involved unfortunately cannot now be reported. The three records now available of the species for the Philippines enable a suggestion that somewhere in those islands may well be the best place to look for an amphimictic population.

Regeneration

Nos. 1-2. With short metamerically unsegmented tail regenerates at 53/54 and 59/60. No. 3. With an eleven segment tail regenerate at 74/75.

Abnormality

No. 3 (Nos. 1-2 in Gates, 1972a). Metameric abnormality frequent in the intestinal region, presumably resulting from asymmetrical somite halving during embryogenesis. Clitellum, lacking in a small V-shaped area near mV in anterior part of xvi. Male porophores, rather definitely outlined, one pair in xviii, an unpaired one in xix, small but normal except for absence of any connection with male gonoducts. One of the prostates of xviii is represented only by a pointed protuberance from the parietes that appears to be equivalent to an ectal portion of a prostatic duct. The nerve cord has a median perforation in each of xxxix and xxxviii and is doubled in xxxi, xxvii and from xxv anteriorly. The discrete cords pass separately to a thickened portion of the peripharyngeal ring. In xvii-xix, the cords were about 2 mm apart ventrally. A short diagonally placed nerve cord with a ganglionic swelling anteriorly was on the parietes in xii-xiii, between the two long

cords. From the ganglion of the middle cord, two nerves pass to the left cord, connections to the right cord were not recognized. A discrete ganglion in x, somewhat median to the left cord is connected thereto by a single nerve. Another nerve from the median margin of the ganglion passes down into the body wall.

An extra spermatheca, normal, was present in ix midway between the two cords. Ducts of the other ten spermathecae entered the body wall lateral to the cords.

The much-browned worm was brittle because of preservation in too strong alcohol. The brittleness prevented obtaining other information.

Parasites

Small spheroidal cysts filled the testis sacs of one Caroline worm. Nematodes were not seen.

Varia

Prof. Conklin's comments on the species which he saw *in vivo* "snaps, twists and flicks violently when touched but does not autotomize". His worms were found under damp top-soil covering sheet rock near spill ways and wet dikes in pond fields" presumably of paddy.

Location of the peri-esophageal blood-gland on the gut anterior to a persistent septum 9/10 (usually almost completely deleted in many pheretimoid species) shows that the glands probably always belong in ix of other species.

The special longitudinal muscle band at mD (Florida worms) is dark red and greatly resembles a turgid blood vessel when visible through the body wall.

Systematics

P. bicincta, according to Sims & Easton (172) rearrangement of pheretimoid species, is the type of a new genus, *Pithemara*. The selection is unfortunate, as an amphimictic population of the type species is unknown. (The generotype, according to some, accordingly is not even a species in a very strict sense.) However, it must be admitted that the aberrations, deletions and modifications (positive as well as negative) that are allowed by parthenogenesis, are actually of the genitalia, most liable to modification.

Pithemara is distinguished from its new sister genera by presence of paired and lateral OR unpaired and ventromedian intestinal caeca and their origin in the region of xxiv-xxii instead of in xxvii. Such lack of definitional precision seems unsatisfactory to the present author who believes that any group of species so closely related as to belong in a single genus should demonstrate that relationship by considerable invariant anatomy, especially in somatic systems such as the digestive, vascular and excretory.

A *sedgwicki* species group also was allotted to *Pithemara*. Little material of that group has been available to this author but it now seems unlikely (at least in part) to be closely related to any other pheretimoid group. *P. sedgwicki* and *mira* (Gates, 1973c) at least, do have certain characteristics that are unknown elsewhere in megadriles. Among the characters involved are those of the ovaries, the very most conservative portion of the entire reproductive system.

Somatic characters of *P. bicincta* that are systematically important are: Presence of intestinal caeca, their pairing, simple shape and location in xxii. Presence of an intestinal typhlosole and its origin in xxii. Completeness of septum 9/10. The excretory system which may be of equal importance systematically, is quite unknown, though there can be little doubt about its being of a highly evolved meroic sort.

Pheretima californica (Kinberg, 1867)

North American records

1867 *Pheretima californica* (part), Kinberg. Öfv. Akad. Forb. 23: 102. (Type locality, Sausolita Bay, California.)

1890 *Perichaeta ringeana*, Michaelsen. Mitt. Mus. Hamburg 7: 10. (Vera Cruz, Mexico.)

1892 *Perichaeta hesperidum*, Beddard. Proc. Zool. Soc. London, 1892, p. 169. (Barbados.)

1904 *Pheretima californica*, Cognetti. Boll. Mus. Zool. Torino 19(478): 2. (Costa Rica.)

1905 *Pheretima californica*, Cognetti. *Idem*, 20(495): 2. (Panama.)

1937 *Pheretima californica*, Gates. Bull Mus. Comp. Zool. Harvard 80(8): 348. (Types of *hesperidum* examined. "Diagnosis" and distribution.)

1942 *Pheretima californica*, Gates. Amer. Mid. Nat. 27(1): 91. (Louisiana. In, Checklist of North American earthworms.)

1943 *Pheretima californica*, Gates. Ohio J. Sci. 43(2): 102. (New Orleans, the second record for the state, 0-0-8.)

1952 *Pheretima californica*, Causey. Proc. Arkansas Acad. Sci. 5: 53. (Arkansas, earthworm farm.) Harman, Proc. Louisiana Acad. Sci. 15: 22. (Lincoln Parish, Louisiana.)

1954 *Pheretima californica*, Gates. Bull. Mus. Comp. Zool. Harvard 111(6): 226. (Louisiana and New York, 0-0-7.)

1958 *Pheretima californica*, Gates. Amer. Mus. Nov. No. 1888, p. 31. (In key to North American species of the genus.)

1963 *Pheretima californica*, Gates. Proc. Biol. Soc. Washington 76: 12. (Vassar College greenhouse, Poughkeepsie, New York, 0-0-2 and New Orleans, 0-0-5.)

1969 *Pheretima californica*, Tandy. Thesis, Louisiana State Univ. p. 25. (Louisiana, 70 sites in 20 parishes of the lower flood plains of the Mississippi and Atchafalaya Rivers.)

Material examined: **FLORIDA.** LEON CO. Tallahassee, yard at 630 West Call Street, 12 Aug 70, 0-0-2, D. B. Means. Campus of Florida State University at Dewey Street, 11 Aug 71, 0-3-6 (V-30) and 0-2-0 (V-31), V. A. Vail. **GEORGIA.** CHATHAM CO. Savannah, 14 Jul 69, 0-0-1 (TF-605), E. V. Komarek, Sr. THOMAS CO. "Georgia wigglers," purchased from Thomas Co., Thomasville, 16 Apr 66, 0-0-8 and 28 Apr 66, 0-6-3, E. V. Komarek, Sr. (Along with the first lot were *P. diffringers* and *hawayana*, with the second lot those two plus *Aporrectodea trapezoides* and *Diplocardia* sp. GEG) Thomasville, 21 Jan 66, 0-2-2 (TC-36), 10 Mar 67, 0-0-134, and 18 Mar 67, 0-0-1, E. V. Komarek, Sr. **LOUISIANA.** BATON ROUGE PARISH, Baton Rouge, 12 Jun 69, 0-8-6 (TF-597), E. V. Komarek, Sr. ST. CHARLES PARISH. Luling, on Route 90, 8 Apr 72, 0-1-1 (DBM-1688), D. B. Means & J. F. Berry. Bonnet Carre, Spillway on Route 1, 9 Apr 72, 0-0-1 (DBM-1689), D. B. Means & J. F. Berry. ST. TAMMANY PARISH, Mandeville, 5 Aug 68, 0-4-1 (TF-418), W. W. Baker & P. E. Jinright. **TEXAS.** BURNETT CO. Burnett, 15 Jun 66, purchased from a bait dealer who claimed that the

worms were dug from rich, local soils, 15 Jun 66, 0-4-24, E. V. Komarek, Sr. **MADEIRA.** Funchal, 20 Jun 26, 0-0-4, G. E. Hutchinson *per* G. E. Pickford. **EGYPT.** Cairo, December 1965, 2-10-34, October 1966, 0-26-14, S.I. Ghabbour.

Interceptions: **ARGENTINA.** From 7½ pound of earth with *Bougainvillea* plant, in baggage on S/S Argentina, arriving at New York, 9 Mar 52, 0-0-1. **AZORES.** From earth with two begonia plants, in baggage on plane arriving at Boston, 5 Aug 59, 0-0-1. From earth with 15 mixed plants and 7 cuttings, in baggage on plane arriving at Boston, 24 Aug 49, 0-1-1. **GREECE.** From earth with five plants in baggage on plane arriving at Detroit, 23 Sept 59, 0-1-0. **PERU.** From earth around plant in baggage on plane arriving at New Orleans, 20 Jan 50, 0-0-1. PORTUGAL. From earth with 5 azaleas, 5 ferns, 2 orchids in baggage on plane arriving at Boston, 21 May 65, 0-0-1.

External characteristics: Segments, 74 (posterior amputee), 82 (2), 83, 85, 87, 89 (2), 90 (2), 91 (2), 92 (2), 93, 95 (2), 96, (98), 99 (many of the preceding specimens may have been posterior amputees), 101 (7), 102 (3), 103 (6), 104 (5), 105 (7), 106 (7), 107 (23), 108 (21), 109 (27), 110 (26), 111 (13), 112 (4), 113 (2), 114 (2), 115 (2). First dorsal pore, ?11/12 (2), 11/12 (63), ?12/13 (7), 12/13 (2).

Setae, in x seemingly smaller than in ix, occasionally in part lacking or perhaps only unrecognizable dorsally, xviii/10, 11, 12, 14 (5 specimens, 15 (3), 16, 18 (2). Formula of a worm with 108 segments, 22/ii, 26/iii, 44/viii, 44/xii, 55/xx, 61/xxx, 63/xl, 64/l, 61/lx, 64/lxx, 60/lxxx, 56/xc, 48/c.

Everted male-pore invaginations (a number of recently examined worms), instead of being columnar with blunt tips, tapered gradually to a fine point. Perhaps in better correlation with size of the spermathecal pores. The porophores sometimes could be described as slenderly conical.

Internal anatomy: The typhlosole usually ended in the region of the 70th-75th segments leaving 26-45 metameres (usually 32-37) atyphlosolate (see Table 3). Dorsal, ventral and subneural blood vessels complete. Hearts, of ix, on the left side only (48), the right side only (39), or present on both sides (3), of x often as large and blood-filled as those of xi but seemingly only esophageal.

Spermathecae, one or both of the anterior pair very often was in vii but occasionally only one or both of the diverticula got forward into that segment.

Reproduction

Spermatozoal iridescence was found on male funnels and in the spermathecae, even of aclitellate individuals. No evidence was found that might warrant suspecting that reproduction is not amphimictic, perhaps even obligatorily so.

Regeneration

Tail regenerates, of two segments at 90/91, three segments at 76/77, 79/80 (2), 81/82, 95/96, of four segments at 63/64, 67/68, 68/69, 82/83, 85/86, of a pygomere without indications of metameric differentiation (several). An Egyptian posterior amputee had healed over without any aperture into the gut (cicatrix imperforate).

Abnormality

No. 1. The left heart of xiii is lacking, two are present on the right side. The anterior one opens only into the supraesophageal trunk. No. 2. Male pore and prostate of the right side lacking. Right male gonoduct ends in bulbous swelling on the body wall in xv. No. 3. An extra pair of spermathecae in vii, with spermatozoa in their seminal chambers and pores at 6/7, is a rare instance of a progressive rather than regressive mutation. In a species possibly with obligatory amphimxis.

Table 3. Typhlosole termination and segment number in *P. californica.*

Segment in which the typhlosole ends.	Number of atyphlosolate segments.	Number of segments in the worm.
61	32	93
58-63	3	67 b
65	26	91
68	18	86 pa
68	33	101
69	20	89 pa?
69	26	95
69	27	96
70	33	103
70	34	104
70	35	105
70	45	115
71	16	87 pa?
71	32	103
71	35	106 c
71	36	107
72	31	103
72	36	108 (2)
72	37	109 (2)
71-73	9	82 pa
73	18	91 pa?
73	26	99
73	33	106
73	34	107 (3)
73	35	108
73	36	109
73	37	110
73	38	111
74	29	103
74	30	104
74	31	105
74	32	106
74	33	107
74	34	108 (2)
74	35	109 (2)
74	36	110
74	37	111 (2)
75	30	105
75	31	106
75	32	107
75	33	108
75	34	109
75	35	110
75	36	111
75	38	113
76	33	109
76	34	110
77	26	103
77	34	111 (2)
81	33	114

[1]58-63, 71-73
Segments in which the typhlosole had undergone regression after posterior amputation.

[2]With a tail regenerate at 63/64.

[3]pa Posterior amputee.

pa? Possible or probable posterior amputee.

[4]Small but fully clitellate St. Helena worm, 72 by 2 mm.

[5]Number of specimens.

Parasites

Cysts, more than 1 mm thick on the coelomic face of the body wall in two specimens.

Distribution

Presence of *P. californica* in eight mainland provinces of China, along with its supposed absence in Japan, led to a belief that China might be the original source of the species. A search for supporting evidence resulted in obtaining the following account that was kindly supplied by Dr. R. C. Miller (*in litt.*, 12 Mar 51) of the California Academy of Science: "In the minutes of the meeting of the California Academy of Science held on January 30, 1854, a resolution was adopted which reads 'That a committee of three be appointed to prepare a memorial to the Board of Supervisors of San Francisco, the object of which shall be to encourage the cultivation of shade trees within the city limits by offering a premium for every tree, which shall be planted and found to be in a flourishing condition within a specified time — the *Ailanthus* to be excluded from the list as unworthy of cultivation.' This would indicate that by the end of 1853 *Ailanthus* had become well established in California. It was undoubtedly introduced by the Chinese, and I have seen specimens growing at Dutch Flats, California, which are stated to have been planted by the Chinese cooks during the gold rush days. There may have been other importations of oriental plants at an early day but the importation of *Ailanthus* alone would be adequate to explain the introduction of *Pheretima.*" Although *P. californica* was collected in California in 1852, as well as in Hawaii, subsequent records for the mainland state are lacking. Did the species fail to achieve permanent domicile there?

Systematics

P. californica, according to Sims and Easton (1972), goes into *Metaphire*. That taxon also is characterized by the classical lack of preciseness. For instance, defining characters are qualified by the following words; rarely (4 times), seldom, occasionally, often (once each). *Metaphire* is distinguished, positively rather than negatively, by presence of copulatory chambers, apparently meaning any kind of an invagination containing a male pore. In *P. californica*, male pores are in small invaginations confined to the body wall. A little further deepening could only have brought their roofs just above the general coelomic level. Male pores of *P. tschiliensis*, for example, are confined to very much larger invaginations that seem unlikely ever to penetrate into the coelom no matter how much greater their further growth. Additionally, the *tschiliensis* invaginations contain genital markings one of which may be quite large. Copulatory chambers, in the present authors terminology, refer to muscular, thick-walled chambers markedly protuberant into coelomic cavities. Such chambers usually contain structures of systematic importance such as genital markings, penes, variously-shaped penial bodies, other porophores, penial or other setae. Such structures, when not ignored, were often inadequately characterized.

Pheretima diffringens (Baird, 1869)

North American records

1867 *Pheretima californica* (part), Kinberg. Öfv. Akad. Forh. 23: 102. (Two paratypes from Sausolita Bay, California.)

1892 *Perichaeta indica,* Michaelsen. Arch. Natg. 58: 252. (Berlin Botanical Garden, in earth from San Domingo.)

1894 *Perichaeta indica,* Michaelsen. Zool. Jb. Syst. 8: 191. (Orvieto, Florida and Savannah, Georgia.)

1895 *Perichaeta indica,* Ude. Zeit. wiss. Zool. 61: 129. (Savannah, Ga.)

1899 *Amyntas indicus,* Michaelsen. Öfv. Akad. Forh. 1899. 56:439. (After examining paratypes of *californica.)*

1904 *Pheretima heterochaeta,* Cognetti. Bull. Mus. Torino 19(462): 2. (Costa Rica, Chemin de Carillo, towards the Atlantic.)

1907 *Pheretima heterochaeta,* Cognetti, Boll. Mus. Torino 19. Atti Ac. Sci. Torinto 42: 790. (Costa Rica, Tablazo, Tejar de Cartago.)

1908 *Pheretima heterochaeta,* Cognetti. Atti Ac. Sci. Torino 43: 913. (Costa Rica, Santa Maria de Dota.)

1915 *Pheretima heterochaeta,* Smith. Bull. Illinois St. Lab. Nat. Hist. 10: 555. (Illinois.)

1925 *Pheretima heterochaeta,* Michaelsen. Mitt. Mus. Hamburg 41: 73. (South Mexico, Finca-Manacol near Tapachula.)

1928 *Pheretima heterochaeta,* Smith. Bull. Ill. Nat. Hist. Surv. 17: 359. (Illinois.)

1929 *Pheretima indica,* Kindred. J. Morph. 47: 441. (Charlottesville, Virginia. Leucocytopoietic organs.)

1933 *"Phaeritima" indica,* Leonard. J. Alabama Acad. Sci. 4:24-25. (Nerve cells.) *Pheretima heterochaeta,* Stephenson. Proc. Zool. Soc. London, 1932: 916. (Duke Forest, Durham, North Carolina.)

1937 *Pheretim diffringens,* Gates. Bull. Mus. Comp. Zool. Harvard 80 (8): 350. (Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina. "Diagnosis", and in key to N.A. species of the genus, p. 342.

1942 *Pheretima diffringens,* Gates. Amer. Midl. Nat. 27(1): 91. (In checklist of North American earthworms.) *Pheretima* sp. *"indica?"* Liebmann. J. Exp. Zool. 91; 379, 380. (Regeneration.)

1943 *Pheretima diffringens,* Gates. Ohio J. Sci. 43: 102. (Fort Myers, Florida.) *Pheretima heterochaeta,* Pearse. American Midland Nat. 29: 413.

1952 *Pheretima diffringens,* Causey. Proc. Arkansas Acad. Sci. 15: 22. (Arkansas, 1 site.) Harman, Proc. Louisiana Acad. Sci. 15: 22. (Louisiana.)

1954 *Pheretima diffringens,* Gates. Bull. Mus. Comp. Zool. Harvard 111 (6): 227. (Alabama, Arkansas, Connecticut, Florida, Louisiana, Nebraska, North Carolina, Oregon, Texas, Virginia, Mexico.)

1956 *Pheretima diffringens,* Gates. Evolution 10: 224. (An amphimictic population of this widely distributed species is unknown. Only various parthenogenetic morphs.)

1957 *Pheretima diffringens,* Graff. Senckenbergiana (Biol.) 38: 126. (Salvador.)

1958 *Pheretima diffringens,* Gates. Amer. Mus. Nov. No. 1888, p. 31. (In key to North American species of the genus.)

1960 *Pheretima diffringens,* Gates. Natl. Speleol. Soc. Bull. 21: 23. (Weaver Cave, Alabama. Although the date on this journal is 1959 this number was not mailed until 21 Jan 60.)

1962 *Pheretima diffringens,* Gates. Proc. California Acad. Sci. (4), 31 (8): 219. (Guatemala. The species is of Asiatic origin.)

1963 *Pheretima diffringens,* Gates, Proc. Biol. Soc. Washington 76: 12. (Greenhouses, central Maine and culture bed of one Maine earthworm farm.)

1965 *Pheretima diffringens,* Bhatti. Proc. Pennsylvania Acad. Sci. 39: 20. (Philadelphia and vicinity.)

1966 *Pheretima diffringens,* Gates. Proc. Biol. Soc. Washington 79: 245. (New Jersey greenhouses. Greenhouse records summarized.)

1967 *Pheretima diffringens,* Murchie. Ohio J. Sci. 67: 53. (Mississippi.)

1970 *Pheretima diffringens,* Tandy. Dissertation, Louisiana State Univ. p. 32. (From 376 sites of 64 parishes, in Louisiana.)

1971 *Pheretima diffringens,* Gates. Assoc. Mexican Cave Stud. Bull. 4: 8. (Mexican caves.)

1972 *Pheretima diffringens,* Gates. Burmese Earthworms, p. 177. (First record for South Carolina.) Bull. TTRS No. 13: 18-44. (Extended synonymy and most North American records to date. Variation, abnormality, regeneration, polymorphism in material from Alabama (3 counties). Arkansas (2), Florida (17), Georgie (20), Louisiana (2), Mississippi (5), North Carolina (11), Pennsylvania (2), South Carolina (6), Tenessee (2), Virginia (1), Mexico, Panama, Jamaica, Hawaii (4 islands).) Reynolds, TTRS Bull. No. 11: 45. (Distribution at *Liriodendron* sites in Great Smoky Mountain National Park, Sevier County, Tennessee. Population density, biomass with reference to moisture, temperature, acidity.)

1974 *Pheretima diffringens,* Reynolds. Megadrilogica 1(11): 7. (Maryland, 4 counties.)

1975 *Pheretima diffringens,* McMahan. Trans. Amer. Micros. Soc. 94: 274. (Protozoan parasites of worms from Baton Rouge East, Louisiana.)

1977 *Pheretima diffringens,* Gates. Assoc. Mexican Cave Stud. Bull. No. 6; (Caves in Puebla and Vera Cruz, Mexico.)

1978 *Amynthas diffringens,* Reynolds. Megadrilogica 3 (7): 120. (Tennessee, many counties. Oklahoma, West Virginia.)

Material examined: **NORTH CAROLINA.** DURHAM CO. Eno River, 1.5 miles north of junction of S. R. 1634 on S. R. 1632, in deep allluvium of sand and leaves, 23 Feb 75, 0-0-13, S. W. Leonard. NEW HANOVER CO. Vicinity of Wilmington, just east of U.S. 421, *ca.* 1/2 mile north of junction with U.S. 17, saturated peat and muck, 23 Feb 75, 0-0-16, S. W. Leonard. **INDIA.** SIKKIM, Gangtok, 500-6000 feet, November, 0-0-56, Capt. Hendricks. Also from gardens at 5000 feet, December, 0-16-20, W. B. Heyes. SOUTHERN INDIA, Coonoor, water channel, 0-0-1 and woods, after rain, 0-0-5, Maj. Iyengar. Ootacamund, December, 1-5-9, Dorothy Pearson.

Interceptions: **VENEZUELA.** From one pound of earth with plant in baggage on plane arriving at San Juan Puerto Rico, 26 Jan 67, 0-0-1. **MADEIRA.** From earth with six assorted plants in baggage on plane arriving at Boston, 14 May 69, 0-1-0.

Distribution

United States: Alabama, Arkansas, California, Connecticut, Florida, Georgia, Illinois,[18] Indiana,[18] Louisiana, Maine,[18] Maryland, Mississippi, Nebraska, New Jersey, New York, North Carolina, Oklahoma, Oregon,[18] Pennsylvania, South Carolina, Tennessee, Texas, Virginia, West Virginia. Costa Rica, Guatemala, Mexico, Salvador, Panama. San Domingo, Trinidad. Argentina, Brazil, Colombia, Peru.

Azores. England, France, Germany, Italy, Netherlands, Poland, Portugal, Russia, Sardinia, Scotland, Sweden, Wales. Anjouan, Cape Verde Is., Egypt, Madagascar, Mauritius, Rhodesia, St. Helena, South Africa.

Burma, China, India, Japan, Korea, Java, Sumatra, Philippines, Australia, New Caledonia, New Zealand, Fiji and Hawaian Islands.

P. diffringens probably has been taken everywhere on this globe that plant-transporting man has gone. Obviously, its colonizing has been limited climatically. "The original home of the species is to be sought in the northern portion of the *Pheretima* domain and perhaps in China, but how much of the range in that county, Korea, Japan and neighboring islands was self-acquired remains to be determined." (Gates, Burmese earthworms, 1972, p. 179)

Presence of the species in every parish of Louisiana was thought (Tandy, 1970) to have been achieved in less than 250 years. Presence in 18 Florida counties, all the way from Dade in the south to Leon in the north now seems to justify a belief the further collecting in the state may find the distribution there to be as complete as in Louisiana. The Asiatic worm has been recorded (Reynolds, 1978) from at least 51 of the 95 Tennessee Counties. Certainly many additional records can be expected in other southern states from North Carolina into Texas.

A record of two specimens of *P. diffringens* from Sausolita Bay in California, as long ago as 1852, remains unique for that state. Did colonization fail there or does the absence of subsequent records advertise our ignorance of the megadrile fauna of a large state with an Academy of Science and great Universities?

With adequate moisture, breeding may be possible throughout the year, even for a climatically restricted megadrile.

Systematics

A *diffringens* species group includes *hawayana, loveridgei, morrisi, robusta,* perhaps *minima,* as well as *pingi* Stephenson, 1925. The author formerly thought (Gates, 1959a, Amer. Mus. Nov. No. 1941, p. 7) that two male-fertile, Formosa worms were "close to, if not identical with, the ancestral hermaphroditic morph". Similar specimens from Hawaii and Georgia were male sterile. The author now wonders if an ancestral amphimictic population really can be found in Taipei.

Pheretima elongata (Perrier, 1872)

North American records

1902 *Pheretima biserialis,* Michaelsen. Mitt. Mus. Hamburg 19: 9. (Puerto Rico.)

1905 *Pheretima biserialis,* Cognetti, Boll. Mus. Zool. Torino 20(495): 2. (Panama.)

1908 *Pheretima biserialis,* Michaelsen. Zool. Jb. Syst. Suppl. 11: 14. (Haiti.)

1937 *Pheretima elongata,* Gates. Bull. Mus. Comp. Zool. Harvard 80(8): 352. (Canal Zone — golf-course greens at Gatun, Cuba, Haiti, Puerto Rico. "Diagnosis".)

[18]Greenhouses only.

1942 *Pheretima elongata,* Gates. Amer. Midl. Nat. 27(1): 91. (In checklist of North American earthworms)

1956 *Pheretima elongata,* Gates. Evolution 10(2): 224. (Reproduction at least in part is parthenogenetic. First instance of somatic change associated with parthenogenesis, abortion of hearts of xiii. Parthenogenetic polymorphism.)

1958 *Pheretima elongata,* Gates. Amer. Mus. Nov. No. 1888: 8. (*Pheretima stelleri* type species of the subgenus *Polypheretima,* is not distinguishable from *elongata* and probably will fall into the synonymy.)

1959 *Pheretima elongata,* Gates. Amer. Mus. Nov. No. 1941: 9. (First report of "severe damage" to agriculture by *P. elongata,* in rice fields on Taiwan.)

1961 *Pheretima elongata,* Puttarudriah & Sastry. Mysore Agric. J. 36:4 (*P. elongata* along with *P. corethrurus* was found to have rendered a south Indian soil compact, hard, cloddy, thus hampering digging, preparation of the soil, rooting of vegetable crops and normal penetration. *P. elongata* constituted 15.6 per cent of the compacted field soil population. But, see *P. corethrurus,* 1963, above p. 39.)

1969 *Pheretima elongata,* Tandy. Thesis, Louisiana State Univ. p. 97.

1971 *Pheretima elongata,* Gates. Evolution 25(1): 247. (Parthenogenesis allowed a return occasionally from a polythecal state to an ancestral quadrithecal condition with two pairs of spermathecae in vi-vii.)

Material examined: Interception. **PUERTO RICO.** From 50 pounds of earth with croton plants (*Codiaeum* sp. Euphorbiaceae) in baggage on M/V Emilia, arriving at Philadelphia, 25 May 60, 0-0-1. (Also material from British Guiana, St. Helena, Hawaii and the Philippines.)

External characters: Size is not exactly small, as the species often reaches a size of 75-300 by 3-6 mm.

Castings

When deposited on the surface, in the largest available plant pots of the author's Rangoon laboratory, were in discrete cords, 20-40 by 2 mm. Or the cords sometimes were aggregated in irregular piles 10-20 mm high and 20-35 mm wide.

Reproduction

Amphimixis is assumed to be possible for thecal individuals that have received foreign sperm in a copulatory act. For others, especially those that are athecal and so cannot receive sperm during copulation, parthenogenesis must be assumed.

Distribution

Peru, Panama, Venezuela, the three Guyanas, West Indies, Egypt, Madagascar, tropical lowlands of India, Pakistan, Ceylon, Bangladesh, Burma (18 districts), Thailand, Malay Peninsula, Taiwan, Philippines, Java, Sumatra, Andaman, Bonin, Celebes, Comores, Coloni, Flores, Hawaii, Kei, New Caledonia, Okinawa, Palao, Riu Kyu, Sumba, Salibaboe, Truk, and Yap Islands.

The species probably had been introduced to the American hemisphere long before 1872 when the type of the species, from Peru, was described. The original home is unknown but perhaps should be sought in a region including the Philippines, Borneo and Celebes.

P. elongata, houlleti and *robusta,* according to Tandy (1969, p. 97), would be prevented from reaching this country via the West Indies where they are domiciled, by the Plant Quarantine Division. *P. houlleti* now is present in two mainland states but has not yet been collected in Florida's southernmost counties where it would more likely be expected. As for preventing earthworm introductions, remarks under *P. houlleti* may be consulted.

Economic Importance

Presence of *P. elongata,* in four different areas, has been thought to have had unfavorable results. The first instance (Gates, 1959: 9) was its appearance, presumably in 1900, in a rice field of Taiwan. By 1910, the worm was in an area of about two hectares and was spreading. The label along with the worms bore the following information: "Earthworms which cause serious damage to rice plants near a small village in central Formosa. They live in soil of a rice field and make numerous tunnels therein, and thus the proper irrigation of the field cannot be made. At present, their occurrence seems to be restricted to about 20 ha, but the range is gradually enlarging. In the area infested the farmers complained that 50 percent of their rice yield was lost during the last ten years simply because of the indirect damage of this worm."

In the second instance (Pattarudriah & Sastry, 1961), compaction that hampered digging and prevented percolation through agricultural soil in south India was blamed on *P. elongata* and *P. corethrurus.* The latter has been accused of compaction of greenhouse soil in a Chatham, New Jersey greenhouse.

The third instance was of seepage losses so severe they caused a court suit. Involved were taro patches on Kauai, Hawaii. The loss of water was attributed to earthworms, that were identified by this author as parthenogenetic morphs of *P. elongata.*

The fourth instance is of water loss from terraced paddy fields at Bayninan, Banaue, Ifuago, Philippines. Prof. Conklin of the Yale Anthropology Department, provided, in addition to the worms the following information: The person, the plot and circumstances involved in the appearance of the species which began to cause serious damage at the area in 1947 were widely known. Cocoons, "eggs" were carried in seedling roots from infected plots during transplantation. Movement upward along the hillsides and even into forested and housing areas had been observed. Burrows go down, in old fields to a depth of several meters. People of Bayninan easily recognize and distinguish the imported species from their own indigenous pheretimas by the following differences: Larger size. Lack of pigmentation. Shape of above-ground castings. Lethargy, ability to stretch without breaking. Ability of an anterior portion to survive when the worm is cut into two or three pieces. A local tale is that the worms supposedly European, first appeared near an outhouse of a Belgian priest at a lower elevation of distant Burnay where it became a nuisance in the thirties.

In Burma, when castings are deposited above ground they may be in discrete cords 20-40 by 2 mm or in irregular piles 10-20 mm high and 20-35 mm wide. Presumably not to be appreciated on any golf green where it once was found (Gates, 1937: 353).

Systematics

P. elongata (Michaelsen, 1934), was in the subgenus *Polypheretima* but according to Sims & Easton (1972) is in the genus *Metapheretima*. The latter taxon was originally proposed by Michaelsen, as the name indicates, for a subgenus of metandric species. *Metapheretima* now is distinguished, (like several of its sister genera, by Sims and Easton), by the absence of esophageal pouches and intestinal caeca (a good beginning!). Other characters of its definition are as usual qualified and by the following words; "or" (5 times), "rarely, occasionally, sometimes" (once each). Presence of copulatory chambers was the character qualified by "sometimes", and is the character supposedly distinguishing *Metaphire* from its sister genera. Essentially then, *Metapheretima* is consistently distinguished from *Metaphire* only by the absence in the former and presence in the latter of intestinal caeca arising in xxvii.

Pheretima hawayana (Rosa, 1891)

North American records

1890 *Perichaeta aspergillum*, Beddard. Quart J. Micros. Sci. 30: 459. (Bermuda.)

1892 *Perichaeta bermudensis*, Beddard. Proc. Zool. Soc. London, 1892, p. 160. (Bermuda.)

1905 *Perichaeta bermudensis*, Harper. Biol. Bull. 10: 18. (Greenhouses, Evanston, Illinois. Reaction to light and mechanical stimuli.)

1909 *Perichaeta bermudensis*, Harper. J. Comp. Neurol. 10: 569. (Tropic and shock reactions.)

1915 *Pheretima hawayana*, Smith. Bull. Ill. St. Lab. Nat. Hist. 10: 557. (The correct name of Harper's worms.)

1937 *Pheretima hawayana*, Gates. Bull. Mus. Comp. Zool. Harvard 80: 335. (New Orleans and Baton Rouge, Louisiana. The Mississippi of the distribution p. 356, is a *lapsus calami* for Louisiana, "Diagnosis".)

1942 *Pheretima hawayana*, Gates. Amer. Midl. Nat. 27(1): 91. In checklist of North American earthworms.

1943 *Pheretima hawayana*, Gates. Ohio J. Sci. 43: 103. (Greenhouses, Hadley, Massachusetts.)

1954 *Pheretima hawayana*, Gates. Bull. Mus. Comp. Zool. Harvard 111(6): 229. (Alabama, California, Florida, Louisiana. Greenhouses, Pana, Illinois, Nashville, Tennessee, Dayton, Oregon. A Jackson, Michigan record was on worms purchased there from a bait dealer who supposedly secured them from Florida. The bait dealer may have been in Lutz, and one (GEG) who raised them for sale there.)

1958 *Pheretima hawayana*, Gates. American Mus. Nov. No. 1888. p. 31. (In key to North American species of the genus.)

1963 *Pheretima hawayana*, Gates. Proc. Biol. Soc. Washington 73: 13. (Greenhouses, Bangor and Ellsworth, Maine, and Chatham, New Jersey.)

1965 *Pheretima hawayana*, Gates. Proc. Biol. Soc. Washington 78: 1-16. (Variation, invariation, abnormality, regeneration, reproduction.) Gates, Proc. Louisiana Acad. Sci. 28: 12. (In list of Louisiana earthworms.)

1967 *Pheretima hawayana*, Gates. Great Basin Nat. 27: 126. (Los Angeles.)

1969 *Pheretima hawayana*, Tandy. Thesis, Louisiana State Univ., p. 58. (One hundred twenty six sites of 36 parishes, Louisiana. Most frequently in flood plains of bayous, creeks, rivers or margins of lakes and swamps of the southeastern section of the state.)

1970 *Pheretima hawayana*, Gates. Rev. Soc. Mexicana Hist. Nat. 3:286. (Two sites in "D.F." Mexico. No proof of this article was submitted. Indeed the author did not know it had been published until Dr. P. Lavelle, on his return from Mexico, presented a xeroxed copy!)

1972 *Pheretima hawayana*, Gates. Burmese Earthworms, p. 190. (New state records, Georgia, Mississippi, South Carolina, Texas. For localities, see below.) Reynolds, Bull Tall Timbers Res. Stn. No. 11: 4, 5, etc. Distribution at 4 *Liriodendron* sites of the Great Smoky Mts. Natl. Park.)

1977 *Pheretima hawayana*, Gates. Assoc. Mexican Cave Stud. Bull. No. 6:3. (Cave, Puebla, Mexico.)

1978 *Amynthas hawayanus*, Reynolds. Megadrilogica 3(7): 121. (Three sites of 3 counties, Tennessee; Diagnosis.)

Material examined: **ALABAMA.** BARBOUR CO. Clayton, 11 Jul 69, 9-40-15 (TC-62A), 0-18-22 (TC-62B), E. V. Komarek, Sr. ESCAMBIA CO. Atmore, 9 Jul 69, 0-0-1 (TC-54A), 0-0-9 (TC-54B), E. V. Komarek, Sr. HOUSTON CO. Dotham, 11 Jul 69, 0-24-16 (TC-63), E. V. Komarek, Sr. LEE CO. Auburn, to the north, 17 Jul 59, 0-0-2, W. A. Murchie. MONTGOMERY CO. Montgomery, 10 Jul 69, 0-18-26 (TC-60), E. V. Komarek, Sr. **FLORIDA.** ALACHUA CO. Gainesville, Hogtown Creek area, 14 Apr 50, 0-2-5, D E. Beck. A few hundred yards west of northwest corner of the university, under cut timber on a hummock, 14 Apr 50, 0-0-1, D E. Beck. 28 Mar 68, 0-0-2 (TF-527A), 29 Mar 68, 1-0-4 (TC-38), E. V. Komarek, Sr. "APPALACHICOLA" County, South of Rock Bluff, 16 Jul 59, 0-0-1, W. R. Murchie. BAKER CO. On Route 127, northwest of Maccelenny, 7 Aug 63, 2-1-0, W. R. Murchie. On Route 125, north of Macclenny, 7 Aug 63, 0-0-5, W. R. Murchie. BAY CO. Panama City, July 1955, 0-0-4, A. S. Lisenby. COLUMBIA CO. Olustee River at Route 38, 26 Jul 59, 1-0-4, W. R. Murchie. DADE CO. Florida City, 6 Dec 67, 0-0-5, 3 Jul 68, 0-1-10 (TF-407), 13 Nov 69, 0-0-17 (TF-688A), 8 Mar 71, 1-1-3 (KO-90), E. V. Komarek, Sr. DIXIE CO. Cross City, under logs on bank under bridge just north of city on Route 19, 0-0-1, E. V. Komarek, Sr. FRANKLIN CO. Carrabelle, 15 Dec 67, 0-0-5, E. V. Komarek, Jr. & Sr. GADSDEN CO. Quincy, 15 Sep 69, 4-76-23 (TF-621A) and 0-64-25 (TF-621B), 0-2-10 (TF-622), E. V. Komarek, Sr. GULF CO. Weewahitchka, 10 May 69, 0-4-20 (TC-49B), 0-0-31 (TC-50A), 0-1-16 (TC-50B), 0-2-19 (TC-50C), E. V. Komarek, Sr. JACKSON CO. Marianna, 2 Apr 68, 0-0-1 (TF-535), E. V. Komarek, Sr. JEFFERSON CO. El Destino Plantation 31 Jul 69, 0-0-1 (TF-610B) and Monticello, 5 Apr 67, 0-0-19, 0-0-5, E. V. Komarek, Sr. LEE CO. North of Caloosahatchee River, 11 Aug 63, 0-0-1, W. R. Murchie. LEON CO. Northwest of Tallahassee, 25 Jul 59, 0-0-1, W. R. Murchie. North Ochlockonee River, 14 Aug 63, 0-0-5, W. R. Murchie. Tall Timbers Research Station, barn lot, 7 May 66, 6-4-5. E. V. Komarek, Jr. Tallahassee, 15 miles north, 15 Feb 66, 0-0-3 E. V. Komarek, Jr. Tallahassee, to the north west, 25 Jul 59, 2-1-0 and 0-1-0, W. R. Murchie. Tallahassee, yard at 630 West Call Street, 12 Aug 70, 0-0-2, D. B. Means. MADISON CO. Honey Lake, east of Greenville, 27 May 66, 0-14-12, 1-5-10, 0-13-18, E. V. Komarek, Sr. Madison, 5 Apr. 67, 0-0-8, E. V. Komarek, Sr. PALM BEACH CO. South Okeelanta, 4 Jul 68, 0-1-2 (TF-410), W. W. Baker & P. E. Jinright. PASCO CO. Manor Ridge, from a bait store where worms had been raised from a batch caught in the woods near Plant City, 12 Oct 71, 0-0-2 (RLC-83), R. L. Crawford & P. E. Jinright. SANTA ROSA CO. Holt, 9 Jul 69, 2-3-4 (TC-53), E. V. Komarek, Sr. SUMTER CO. Dade Battlefield Memorial Park, in and around worm bed in back of Superintendent's house, 14 Oct 71, 1-0-2 (RLC-93), R. L. Crawford

& P. E. Jinright. SUWANNEE CO. Live Oak, 5 Apr 67, 0-1-55, 0-3-15-1, E. V. Komarek, Sr. TAYLOR CO. Williams Landing on Aucilla River, near bridge, 22 Aug 66, 0-1-13, E. V. Komarek, Jr. & Sr. UNION CO. On Route 213 north of Lake Butler, 6 Aug 63, 0-0-2, W. R. Murchie. VOLUSIA CO. Allandale, 5 Dec 67, 0-0-19, E. V. Komarek, Sr. and 28 Dec 67, 0-1-2, 27 Jun 68, 0-0-1 (TF-573), 0-0-1 (TF-574), W. Wetherill. Daytona Beach, 10 May 68, 0-0-1, W. Wetherill. WALTON COUNTY. Freeport, to the south, 14 Jul 59, 0-0-1. East of junction of Routes 20 and 313, 13 Jul 59, 0-1-0. Northeast of Freeport, 14, Jul 59, 4-0-1. East of Freeport, 15 Jul 59, 0-1-0. North of Freeport, 20 Jul 59, 0-2-0, 0-1-0. Route 20 at Choctawhatchee River, 14 Jul 59, 0-0-5 and 2-2-2. Pleasant Hill, 22 Jul 59, 0-0-2. All by W. R. Murchie. **GEORGIA.** BAKER CO. Cookawachee Creek, 4 Dec 70, 0-0-1 (DBM-1461), D. B Means. BIBB CO. Macon, 14 Sep 66, 0-0-55, E. V. Komarek, Sr. BROOKS CO. Pavo, to the east, 0.4 miles west of intersection of Routes 33 and 122, 17 Jan 72, 2-1-2 (PEJ-8), P. E. Jinright. CAMDEN CO. Kingsland, 5 Dec 67, 0-5-23, W. W. Baker. CHATTAHOOCHEE CO. Fort Benning, top four inches of soil in forest area a few feet above Chattahoochee River, 16 Apr 50, 0-0-1, D. E. Beck. CHATHAM CO. Warsaw I., sandy soil under log, 26 Oct 70, 0-0-2, E. V. Komarek, Sr. CRISP CO. Cordele, 13 Sep 66, 0-6-78, E. V. Komarek, Sr. DODGE CO. Eastman, 16 Sep. 66, 0-0-3, E. V. Komarek, Sr. GRADY Co. Beachton, 20 Nov 66, 0-0-6, 27 May 67, 0-0-1, 3 Jun 67, 3-1-2, 20 Jul 67, 1-1-0, 9 May 70 (KO-39A), Aug-Sept 71, 0-8-206, 3 Oct 71, 0-0-6 (KO-118), 4-8 Oct 71, 0-0-3 (KO-122), 13 Oct 71, 4-2-1 (KO-123), 16 Oct 71 0-0-2 (KO-124A), 0-6-2 (KO-124B), 15 Oct 71 0-0-6 (KO-126), 16 Oct 71, 0-0-5 (KO-131), 17 Oct 71, 0-1-5 (KO-135), 25 Dec 71, 0-1-0 (KO-150C), 21 Dec 71, 0-1-7 (KO-152B), E. V. Komarek, Sr. Birdsong Plantation, 11 miles south of Cairo, Feb 66, 0-1-3, 29 Mar 66, 1-1-2, 3 Apr 66, 0-1-0, 14 miles south of Cairo, 23 May 66, (some of 56?)-0-3, 12 miles south of Cairo, 24 Aug 66, 0-2-10, (some of 35?)-0-3, 10 May 71, 12-2-5 (KO-87A), E. V. Komarek, Sr. Crawling over walk at Birdsong, 15 May 66, 0-0-1 Betty Komarek. Birdsong, 17 Apr 67, 0-0-4, base of Birdsong bird-bath 28 Apr 66, 1-2-3, E. V. Komarek, Sr. Sherwood Plantation, 17 May 68, (1?)-1-11 (TF-364) and 0-0-1 (TF-367), W. W. Baker. HARRIS CO. Hamilton, 4 Aug 67, 0-0-2 and 1-1-0, E. V. Komarek, Sr. PULASKI CO. Hawkinsville, 13 Sep 66, 0-5-43, E. V. Komarek, Sr. THOMAS CO. Boston, 27 Oct 66, 0-0-5. Boston, 2 Feb 72, 5-10-37 (KO-196A), 7-16-35 (KO-196B), 0-0-26 (KO-196C), E. V. Komarek, Sr. Boston, 2 Feb 72, 5-10-37 (KO-196A), 7-16-35 (KO-196B). 0-0-26 (KO-196C), E. V. Komarek. Boston, Linton Lake, Sedgwicks 15 Jul 67, 0-0-1. Bar M Ranch, 18 Jul 67, 0-2-1, 19 Jul 67, 0-3-1 and 0-0-1, 25 Jul 67, (6?)-11-12, 4-3-33, 3 Aug 67, 0-0-3, 6-3-38, (3?)-2-1, W. W. Baker & P. E. Jinright. Thomasville, Sedgewicks, millpond plant, 14 Aug 67, 0-2-12, Thomasville, low area of hardwood within Thomasville city limits, 10 Mar 67, 0-0-5, Another area within the city limits, 18 Mar 67, 0-0-6 (TF-112), 18 May 66, 0-1-31. Powell's nursery beds, 26 Sept 66, 0-11-311. Metcalf, 18 May 66, 11 (+some of 35?)-0-45. Heards Pond, 14 Apr 66, 0-0-4. Purchased from Thomas Co., 21 Jan 66, 0-25-39 (TC-36), 16 Apr 66, 0-6-30, 28 Apr 66, 0-0-1 (With the 1st lot were *P. californica* and *P. diffringens.*) Greenwood Place, 22 Dec 71, 0-0-8 (KO-148A), E. V. Komarek, Sr. TIFTON CO. Tifton, in bed back of garage, Ferry Creek Road, 27 Sep 66, 0-1-35. In outdoor bed behind shed of Tifton Bait Shop, 27 Sep 66, 0-1-8, E. V. Komarek, Sr. WARE CO. Waycross, carpet-grass covered, rather stiff clay, in back yard of J. C. Howard, 0-0-2, E. V. Komarek, Sr. WAYNE CO. Doctortown, banks of Altamaha River, 13 Aug 61, 0-0-1, K. I. Boss & S. L. H. Fuller per Wm. Clench. Jessup, 15 Jul 69, 0-9-5 (TF-601), E. V. Komarek, Sr. **LOUISIANA.** BATON ROUGE PARISH. Baton Rouge, 12 Jun 69, 0-7-5 (TF-597), E. V. Komarek, Sr. St. Tammany Parish, Mandeville, 5 Aug 66, 0-1-2 (TF-418), W. W. Baker & P. E. Jinright. **MISSISSIPPI.** PEARL RIVER CO. Poplarville, 24 Mar 71, 0-0-2 (TF-754), E. L. Crawford & D. B. Means. **TEXAS.** BURNET CO. Burnet, 15 Jun 66, purchased from a dealer who claimed his worms were dug from a rich local soil, 0-0-1, E. V. Komarek, Sr. HAYS CO. Tarbutton's Cave, 10 miles northeast of San Marcos, 7 Sep 63, 0-0-7 (Said to be fairly numerous throughout the cave where they supposedly had been present for at least four years. Associated with a planarian, possibly *Bipalium kewense.*) B. Russell.

FRENCH POLYNESIA. Moorea, Society Island, damp spot by a waterfall at 2,000 feet, in Matapoopoo Valley, west side of Rotui Mountain, 30 Jun 62, 0-0-1, Elizabeth Murray. **INDIA.** Sikkim, Gangtok, 550-6,000 feet, November, 0-0-6, Capt. Hendricks. Sikkim, Gangtok, from gardens at 5,000 feet, 0-28-42. **MADEIRA.** Funchal, garden, 20 Jun 26, 0-0-1, G. E. Hutchinson *per* G. E. Pickford. **SINGAPORE.** University of Malaya premises, 0-0-14. Fourth mile on Bukit Timah Road, 0-0-3 and 0-0-4, C. H. Fernando. Singapore Island, 11 Nov 62, 0-0-1, 7 Sep 62, 0-0-1, 1 Mar 63, 0-1-0 and 0-0-1, W. C. Chia.

Interceptions: **BERMUDA.** from sphagnum moss with hibiscus plants arriving at Hoboken, 8 Jul 59, 0-0-1. **BRASIL.** from earth for nematode analysis in baggage on plane arriving at New York, 11 Jun 1962, 3-0-0. From earth with 7 rooted cuttings of *Bougainvillea* sp., in cargo on plane arriving at New York, 11 Jun 62, 3-0-0. **GUATEMALA.** From orchid plants in cargo arriving at Laredo, Texas, 18 May 49, 0-0-2. **MEXICO.** From earth with fern plant in baggage arriving at El Paso, 7 Aug 53, 0-0-1. From 5 pounds of earth with fern plants from Aguas Calientes, arriving in passengers baggage at El Paso, 1 Jun 1956, 2-2-11. From earth with plants from Chihuahua arriving at El Paso, 1 Jun 56, 0-0-1. From 11 pounds of earth from Cuernavaca, Morelos, arriving in passenger's baggage at El Paso, 2 Jul 56, 0-0-2. With orchids from Guadalajara, Jalisco, in baggage on auto arriving at Nogales, 18 Sept 57, 0-2-0. From 5 pounds of earth with *Rubus* sp., in baggage on auto arriving at Brownsville, 16 Dec 59, 0-0-3. From Earth with three plants in tourist car arriving at Laredo, 2 Sep 60, 0-2-0. From earth with 20 cactus plants in baggage on car arriving at Brownville, 12 Sep 60, 0-1-0. From earth with 2 plants of *Bougainvillea* sp., in baggage on car arriving at Nogales, 4 Jan 61, 0-0-4. With 2 fern plants from Tamazunchale, San Luis Potosi, in baggage on car arriving at Brownsville, 3 Jan 66, 0-1-0. From earth with plants of *Jacaranda* sp, on auto arriving at Nogales, 5 Jan 66, 1-0-0. From earth with one plant of Amaryllidaceae (*Hippeastrum* sp.?) from Cuernavaca in baggage on auto arriving at San Luis, 18 Feb 66, 2-0-0 (and some fragments). **SALVADOR.** From earth with plants in passengers baggage on plane arriving at San Pedro, 19 Jul 56, 0-0-1. **VENEZUELA.** From 1 pound of earth with plants in baggage on plane arriving at San Juan, Puerto Rico, 26 Jan 67, 0-0-6. **PORTUGAL.** From earth with 3 plants of *Mentha* sp., 3 plants of *Lilium* sp., 2 plants of *Ficus* sp., in baggage on plane, arriving at Boston, 27 May 65, 0-2-0. From earth in baggage on SS Lurlin, arriving at San Pedro, 26 Jan 50, 5-0-0. From earth with plants in baggage on SS Steel Scientist arriving at New York, 14 May 51, 0-0-1. From osmunda fiber with *Anthurium* sp., in passenger's baggage on SS Avila arriving at San Pedro, 6 Sep 55, 1-0-0. From earth with *Anthurium* sp., in baggage on SS Hawaiian Farmer arriving at San Pedro, 16 Aug 57, 0-0-1. From 15 pounds of earth with 2 *Anthurium* plants in baggage Tkr. Point Arena, arriving at Portland, Oregon, 7 Jul 63, 0-0-1. From earth with 2 plants, *Raphis* sp., in baggage on USN Constant, arriving at Los Angeles, 18 Mar 64, 0-0-2. (Additionally several hundred specimens from 6 Hawaiian Islands were examined.)

External characteristics: Setae, of x (often the longest segment) in part lacking dorsally or so deeply withdrawn as to be invisible externally. The buccal cavity can be everted so as to protrude 3.5 mm beyond the anterior edge of the peristomium. The protrusion is sometimes greater than the combined lengths of i-ii. First dorsal pore of specimens examined since the previous account, at 9/10(3) 10/11(132), ?11/12 (3), 11/12 (4(, the first functional pore often was smaller than those following.

Postsetal genital markings may also be present in some preclitellar segments, where they are median to the spermathecal pores and usually closer to the intersegmental furrows than to the

segmental equators. They are located as follows, in vi (4), vi-vii (6, doubled in vi once), vii (407, doubled in 8 specimens), vii-viii (36), viii (4, doubled in one). Some Georgia collections had such markings in unusually high proportions, for instance, 26 of 35, 132 of 165 and 151 of 214 specimens. A postsetal median marking was seen only once and then in vii.

Reproduction

Careful search during many years for any evidence that might indicate a possibility of parthenogenesis has been in vain (*cf.* Gates, 1965: 14.).

Regeneration

At an anteriorly exposed surface. No. 5. After loss of segment i-iii, lv-v became elongated with loss of their setae (morphallaxis). The new peristomium and prostomium that was formed was abnormal.

Following amputation, probably almost exactly at 10/11, an imperforate cicatrix was formed. An autotomized tail of 35 segments had formed an imperforate cicatrix. The two first substrate segments had lost all of their setae, and most of their size and then, along with the cicatrix, formed the anterior face of the fragment. Being unable to eat, the worms presumably died. Similar conditions in species with much higher regenerative capacities also were fatal.

At a posteriorly exposed surface. Tails, of 10 segments at 41/42, of 16 at 45/46, of 5 and 7 at 51/52, 8 at 53/54, 16 at 54/55, 16 at 55/56, 11 and 12 at 57/58, 3 at 62/63, 8 at 63/64, 7 at 66/67, 6 at 67/68, 7 and 9 at 69/70, 5 at 73/74, 4 at 74/75, 8 at 75/76, 4 at 79/80, 5 at 83/84, 4 at 86/87.

After its tail had been torn off in the region of xl-xli, one worm had healed over posteriorly so that the imperforate cicatrix had made defecation impossible. A similar development in experiments on species with an unusually high regenerative capacity almost always ended fatally. Only very rarely did a worm survive the rupture caused by the accumulating ingesta.

Adolescent Stages

Different degrees of early adult development seemingly could be arranged as one long series in the following sequence: 1) Slight narrowing of segments xiv-xvi (due to thinning of the epidermis?). 2) Disappearance of setae (discharged externally? or at least in part into the coelomic cavity?) first in xv, then in dorsum of xiv (sometimes also in xvi), then in ventrum of xiv (and dorsum of xvi), finally in xvi. 3) A non-descript change in appearance of the epidermis but as yet without any distinguishable tumescence between 13/14 and eq/xvi. 4) Disappearance of 14/15 and 15/16 along with occlusion of their dorsal pores.

Abnormality

(continued from Gates, 1965a). No. 13. Right spermatheca of viii with two diverticula which are adherent to each other throughout and pass together into the parietes on anterior face of the duct. No. 14. An extra, slightly smaller spermatheca on right side of viii, with its pore about 1 mm lateral to that in the normal position. No. 15. Two spermathecal pores close together at 8/9 on the right side, each spermatheca a normal organ and with sperm in the seminal chamber. No. 16. Two spermathecal pores close together on left side of 7/8, each opening into a normal organ. No. 17. An extra spermatheca in ix on the left side with a pore at 8/9. A ventral portion of 8/9 is persistent on the right side and perhaps a trifle stronger than usual. Left and right hearts of ix and of x are larger than usually and blood-filled. No. 18. An extra spermatheca in ix on the left side with a pore at 8/9. Left half of 8/9 is slightly muscularized, the right half aborted as usual. No. 19. An extra male porophore with prostate and associated genital markinga, in xvii on right side. No. 20. Extra male porophore and prostate in xix on right side. The posterior prostate is smaller and its duct is shorter than normal. No. 21. Abnormal metamerism in region of xiii-xv. As a result, the left male terminalia seems to be one segment anterior to that on the right side. Nevertheless, if segments are counted along certain meridians of longitude, both male pores are in xvii. Internal organization of i-xii is normal. No. 22. Right side, clitellum lacking in xvii but setae of that segment present in a complete circle, male pore in xvii, intestinal caecum arises one segment anterior to that on the left side. No. 23. Metamerism normal. Male terminalia lacking on both sides. Male gonoducts unrecognized. Male sterile but the worm had succesfully copulated! Finding such a specimen was most unexpected in view of the previously expressed opinion that available evidence indicated amphimixis to be obligatory (Gates, 1965a: 14).

Varia

Seven specimens of a recently examined series were not certainly identifiable externally because genital markings were absent and spermathecal pores were unrecognizable. Six, with 81 (possibly an old tail regenerate at 64/65), 84, 93 (2), 94 and 95 segments respectively, each had the first dorsal pore at 10/11. Dissection confirmed the tentative identification of *P. hawayana*. A seventh specimen, having the first dorsal pore at 11/12, was dissected and identified as *P. diffringens*. However, too much importance should not be placed on location of the first dorsal pore, because of difficulties of its determination in many specimens.

Systematics

According to Sims & Easton (1972), *P. hawayana* is in *Amnythas* but associated with different species than seem appropriate to this author.

Pheretima hilgendorfi (Michaelsen, 1892)

North American records

1954 *Pheretima hilgendorfi,* Gates. Bull. Mus. Comp. Zool. 111(6): 230. (New York State, 2 counties, Michigan and Virginia, 1 county each, All specimens without male pores. Reproduction parthenogenetic because of male sterility.)

1958 *Pheretima hilgendorfi,* Gates. American Mus. Nat. Hist. Nov. No. 1888, p. 11. (Louisiana, one parish, Each specimen is male sterile and lacks male pores.)

1966 *Pheretima hilgendorfi,* Gates. Proc. Biol. Soc. Washington. 79: 246. (A Connecticut greenhouse.)

1969 *Pheretima hilgendorfi,* Tandy. Thesis, Louisiana State Univ. p. 74. (Louisiana, 8 sites.)

1978 *Amynthas hilgendorfi,* Reynolds. Megadrilogica 3(7): 122. (One site, Tennessee. New state records for Arkansas, California, Oklahoma, South Carolina, Tennessee and Texas, for further data see below.)

Material examined: **ARKANSAS.** SEVIER CO. Horatio, 3 Jul 68, 0-0-4, Ottys Sanders. Horatio, 15 miles north, summer 68, 0-0-4, Cartes Arner *per* O. Sanders. **CALIFORNIA.** LOS ANGELES CO. Sierra Madre, soil, 20 Oct 58, 0-0-2, L. E. Myers per U. S. Dept. Agric. Sierra Madre, in soil under avocado tree, 506 West Grandview, 0-0-3, L. E. Myers *per* A. W. Bell. **CONNECTICUT.** FAIRFIELD CO. Greenwich, in compost heap near Saxon-Krueger greenhouses, 26 Aug 57, 0-0-6, 28 Oct 57, 0-0-3, GEG. In and under leaf piles, under logs, in woods by Beckerley residence, Riversville Road, 10 Aug 60, 0-12-15, GEG. **LOUISIANA.** ASCENSION PARISH, bought in St. Francisville bait shop, 12 Jun 69, 0-0-10 (TC-51), E. V. Komarek, Sr. LIVINGSTON PARISH, Denham Springs, 7 Apr 70, 0-10-0 (KO-27A), E. V. Komarek, Sr. ST. LANDRY PARISH, Washington, 6 Aug 68, 0-0-25 (TF-419), W. W. Baker & P. Jinright. Baton Rouge, purchased from bait shop, 12 Jun 69, 0-2-58 (TC-52A), E. V. Komarek, Sr. **NEW YORK.** WESTCHESTER CO. Millwood, in garden, 5 Oct 58, 0-0-3, L. H. Hyman. NASSAU CO. Sea Cliff, lawn at 231 Littleworth Lane, fall 58, 0-0-4, J. F. Cornman, R. G. Mower, R. O'Knefski. (American Mus. Nat. Hist. No. 3586.) **OKLAHOMA.** McCURTAIN CO. Idabel, 14 Aug 68, 0-0-3 (TF-454), W. W. Baker & P. E. Jinright. Broken Bow, 14 Aug 68, 0-0-1 (TF-457), W. W. Baker & P. E. Jinright. **SOUTH CAROLINA.** DARLINGTON CO. Hartsville, 13 Oct 69, 0-0-26 (TF-646), E. V. Komarek, Sr. 10 Aug 71, 0-3-52 (RLC-76). D. B. Means & R. L. Crawford. JASPER COUNTY, Highland, 15 Jul 69, 0-0-9 (TF-603A), E. V. Komarek, Sr. **TENNESSEE.** MONROE CO. Cherokee National Forest, 13 Sep 68, 0-0-1 (TF-486), W. W. Baker. **TEXAS.** WALKER CO. Huntsville, 15 Jun 66, 0-0-49, E. V. Komarek, Sr. (These worms were purchased from a bait dealer who gets them from southern Louisiana. He also ships them to Cleveland, Ohio.)

JAPAN. HOKKAIDO: Kuchan, from a farm in the suburb of this town, 4 Aug 59, 1-0-0 and from a second pine forest in the suburb, 4 Aug 59, 0-1-2. Mt. Yotei, from a bush at foot of the mountain, 5 Aug 59, 4-8-1. Hangetsu, lakeside at foot of Mt. Yotei, from a natural fertile field, 5 Aug 59, 0-9-0. Mt. Yotei, near a bush by bamboo half way up the mountain, 5 Aug 59, 0-1-0. Mitsumata, from side of a house, 7 Aug 59, 0-9-1. Kamishihoro, from side of a house, 7 Aug 59, 0-5-5. Kamiobihiro, from side of a house, 8 Aug. 59, 0-0-2. Karikachi Pass, 9 Aug 59, near symbolic entrance of a shrine, 0-0-12, a natural field, 0-10-4. Furano, from natural fields near a farm, 9 Aug 59, 0-0-3. Tenjinkyo, Hagomore Falls, near basin of the waterfall, 10 Aug 59, 0-0-14. Tomokomai, near the city, 12 Aug 59, 0-8-0. All by students per S. Kobayashi. **USSR.** KURILE ISLANDS, Kunashir, 13 Jul 51, 0-0-1, 20 Sep 70, 0-6-0 (Each of the Kunashir worms had genital markings in viii. One lacked male porophores.)

External characteristics: Size (contracted), to 155 by 8 mm. Segments, 57-100 (23 specimens, each of which obviously or probably was a posterior amputee), 101, 103 (2), 104 (2), 105 (2), 106 (6), 107 (9), 110 (10), 111 (6), 112 (3), 113, 115, 117; 97, 104, 107 (2), 109 (3), 110 (3), 111 (2), 112 (3), 113 (3), 114 (2), 117, 118 (unamputated, Louisiana specimens counted by Tandy and provided present author *in litt.*); 65-109 (39 specimens, each of which was obviously an old posterior amputee or recently autotomized perhaps at time of collection), 95 (5), 96 (7), 97 (5). 98 (3), 99 (3), 100 (2), 102, 106 (2), 107, 108 (4), 109 (3), 110 (3), 111 (4), 112, 113, 115 (2), 116 (Japanese specimens). Average number of segments (7 unamputated Kamishihoro specimens), 108.7. Color, in preclitellar dorsum, as well as ventrum of ii-iv, slate to dark blue or brownish, posteriorly, light brownish or reddish brown. Prostomium, epilobous, tongue open (all). First functional dorsal pore, at 12/13 (all), not 11/12! No white, or even lighter colored, equatorial intrasegmental bands were recognized on any specimen. Setae, 52-65/xxx, 43 on 89th of 93 segments, 56 on the 105th of 108 segments. Setae were unrecognizable in the last two or three segments of unamputated individuals and usually were present only in the ventrum of the last setigerous segment.

The minute male pores of an adolescent Kunashir worm superficial, each in a small, circular to shortly illiptical, flat-surfaced disc. A circular furrow demarcating the flat disc was deep but not enough to allow any retraction of the disc. Nor were the peripheral margins of the groove capable of being drawn over the disc to cover any part of it in any way. That stage of development may have been terminal for the Kunashir worm as it seemed almost exactly the same as on one fully clitellate American adult. The external apertures of several Japanese worms were rather widely separated, transversely slit-like equatorial apertures between which were 15-20 setae. The anterior and posterior lips of such slits were finely rugose. Porophores on roofs of the cavities were not flat discs but were glabrous and were raised into a low dome-shape or of an almost hemispheroidal appearance. The roof of each invagination protruded slightly into the coelomic cavity. Slicing off that roof as closely as possible to the general coelomic surface revealed no trace of any space. The lumen of the invagination accordingly is confined to the parietes and does not, according to this author's terminology, allow the invagination to be called a copulatory chamber (a term reserved for those structures reaching well into the coelomic cavity). The parietal invagination presumably is at least partially eversible or protrusible. The single instance seen of protrusion, was described at the time as, "a high protuberance of glabrous surface with a male porophore at its ventral end. Except for the terminal disc, no definite shape, such as conical or penial, was recognized. *P. hilgendorfi* can now be defined as having its minute, primary male pores invaginate rather than superficial. What still remains to be determined is whether the species is to be defined as having its minute and primary male pores in parietal invaginations limited to the body wall or in coelomic copulatory chambers.

The number of male pores per individual varied from one to four. A batch of nine Hangetsu worms had a total of 22 male pores. Many other individuals had none at all.

Spermathecal pores, very small transverse slits nearly 1/2 C apart, at 6/7-7/8 when a normally complete battery is present. (Are minute, primary spermathecal pores within some parietal invagination or even coelomic chambers in any existent amphimictic population?

Genital markings, quite small, circular discs, each seemingly with a single, central aperture. They almost always are crowded together into rather irregular, transverse rows, several of which are contained within unpaired and median, presetal patches. The latter were in some or all of viii-ix and xvii-xviii but occasionally were present in vii, x-xi, even xix-xxii. Numbers of markings counted in several patches, 10, 13, 16, 18, 24, 30. On many specimens the number of markings per patch was much smaller. Reduction in size of the circular markings and of their associated glands never was noted. Reduction of number of markings per patch of viii or ix obviously had been under way in some series. With reduction of the markings of ix to a single row, the epidermis of the surrounding region had become thin, finely wrinkled or cross-hatched, sometimes with a faint brownish color.

Internal anatomy. The special, longitudinal muscle band at mD, with considerable pigment, attenuates or disappears in xii though occasionally almost reaching 11/12. Pigment, in circular muscle layer, red. Septa, 8/9-9/10 at least in large part aborted, any of 15/16-19/20 may have a rather obvious pocket near the ventral parietes and usually just lateral to the level of the male gonoducts. The pockets, always empty and collapsed reached at least halfway forward or backward to an adjacent septum.

The glandular collar on the esophagus, probably belonging to ix is low. Intestinal origin, in xv (74), Typhlosole, rudimentary from xvi to caecal segment from whence it is simply lamelliform into region of segment xl, posterior to which the fold becomes more irregular with height gradually decreasing, the termination

not distinct, but no trace recognized after the 79th (of 113) or the 74th (of 99 segments). Ventral typhlosole, horizontally ribbon-like but with a groove at mV, in 16-17 post-caecal segments. In front of the caecal segment, the intestine is deeply sacculated. Caeca, manicate, secondary pockets decreasing in size ventrally.

Subneural trunk, on parietes, traceable into iil where it bifurcates under the subesophageal ganglion. Hearts, of ix on the right side only (35), on the left side only (23), of x lacking (74), present on the left side only (1), the right side only (2), on both sides (2, but slender), of xi-xiii latero-esophageal (76).

Testis sacs, unpaired and ventral. Prostates, when present, usually large in segments xv-xxi. Their ducts, to 6+ mm long, with muscular sheen, in a C-or a U-shape, a gradually narrowed portion in the body wall may be 2 mm long. Male gonoducts, without epididymes, pass to ental ends of the prostatic ducts when the glands are present but otherwise end anywhere in the region of xvi-xxiv, often asymmetrically. They may attenuate or end in a thin-walled, fluid-filled vesicle. One such contained a little brown debris. Spermathecal ducts, shorter than the ampullae, with muscular sheen, markedly narrowed in the parietes, lumen of coelomic portion irregularly slit-like due to presence of low longitudinal ridges. Diverticulum, from median face of duct at parietes, longer than the main axis, it's stalk with muscular sheen and small, circular central lumen, the seminal chamber elongately sausage-shaped. GM glands long stalked and coelomic.

Reproduction

Obligatorily parthenogenetic because of male sterility in all material seen by this author.

Distribution

Japan, Korea (Koryo and Keijo). U.S.A., Arkansas (1 county), California (1), Connecticut (1), Louisiana (3), Michigan (1), New York (3), Oklahoma (1), South Carolina (2), Tennessee (1), Texas (1), Virginia (1). The species has not been recorded from greenhouses, or any other site in the state of Maine (Reynolds, 1978: 122).

Abnormality

(Omitting all mention of degradational and deletional changes in the genitalia ordinarily allowed by parthenogenesis.) Nos. 1-7. Each of these specimens, from a Louisiana lot of 60 (TC-52A), had a single female pore in xiii, slightly to the left of mV (4 specimens), or slightly to the right of mV (3 specimens). The asymmetrical placement of the pore indicated presence in xii and on the side mentioned, of an ovary (with ova) and along with it, a female funnel and on oviduct. An ancestral condition that was lost untold thousands of generations ago has been restored on one side of the body only for each individual.

No. 8. A fifth and normal spermatheca is present with its external aperture on the right side at 5/6.

No. 9. Septum 8/9 complete though membranous but strong. (Another instance of reversion to a former condition.) Right heart of xiii, lacking.

No. 10. Clitellum, in xii-xiv. Female pore, in xii. GM patches, in vii, xv, xvii. Peristomium with some setae. The first two segments, perhaps with a small portion of iii, may have been excised, after which a prostomium was regenerated and a mouth reconstituted.

No. 11. Segment iii is wider on the left side than on the right side, and has there a groove just like an intersegmental furrow but just behind the setae. On the right side, segment ix is narrow and without setae. Clitellum, in xv-xvii on the right side, in xvi-xviii on the left side. Female pores, in xv and xvi. Internal anatomy, on the right side: Testis sacs, in xi-xii. Seminal vesicles, in xii-xiii and pseudovesicles in xiv. Ovary, in xiv. Intestinal origin in xvi, caeca in xxviii. Hearts, of x lateral, of xi very slender, of xii-xiv latero-esophageal. On the left side: Testis sacs, in xi, xii, xiii, seminal vesicles in xii, xiii and xiv. Hearts, in xi-xv. Intestinal origin in xvii, caeca in xxix. Ovary, in each of xiv-xv.

No. 12. Female pores, median or nearly so, in xiv and xv. Clitellum, on left side in xv-xvii, ending almost exactly at mD and mV in xiv and xvii. Septa; 10/11 of the right side ends at gut mesially but dorsally passes to the septum next behind, 11/12 of the right side is continuous with left 10/11. The first heart of the left side joins the ventral trunk at the same level as the right heart of xii. Testes, seminal vesicles, last hearts, intestinal origin and intestinal caeca of left side one segment behind the usual location. No metameric abnormality was recognizable externally but the specimen was soft.

No. 13. Metamerism abnormal in the postclitellar portion of the body. No. 14. A spiral abnormality involving iii-iv was recognizable only on the left side. No. 15. A wedge-shaped segment on the left side behind the clitellum, seemingly had no equivalent anywhere on the right side.

No. 16. The clitellum of this worm extended on the left side back from xxvi. The abnormality like that of the holotype of *Helodrilus relictus* Southern, 1909, had resulted in extensive splitting of embryonic somites, in this instance that normally would have given rise to segments iii-xxxv. Asymmetry was involved and it has obviated a satisfactory explanation. This is the first instance of extensive *relictus* type somite splitting outside of the family Lumbricidae.

A male pore and an associated prostate, on one or both sides of the body, was present in xvi (4 specimens), in xvii (21 specimens).

Parasites

An insect larva in coelomic cavities of the intestinal region, was found in each of two specimens. Presence of the parasite was indicated by a parietal aperture with a smooth but slightly tumescent margin, in the dorsum of xxi-xxiv just to the right of mD, or almost at mD of xix.

Medium-sized cysts, possibly of gregarines, were present on coelomic face of the parietes from iv to the very hind end (Tomokomai specimen).

Systematics

P. hilgendorfi is effectively known at present, at least by that name, only from male-sterile morphs. Such worms of course must reproduce parthenogenetically. The author has been demonstrating for a number of years, that parthenogenesis allows almost all organs of a complex, hermaphroditic, megadrile, genital-system to be variously modified, even deleted without leaving any vestiges, during a period that is too short for any evolutionary changes in somatic systems to become recognizable. The only exceptions to the rule are; ovaries, oviducts and a clitellum that secretes the cocoons in which development takes place.

The *hilgendorfi* morphs are numerous and vary in many different ways. The problem they pose is that of determining from isolated and incompletely or defectively developed structures how the genitalia of the ancestral, amphimictic population can be

characterized. Hitherto it had been supposed that male pores of the amphimictic population were superficial "discharging directly onto the surface of xviii" (Reynolds, 1978: 119). That character enabled Sims and Easton (1972), in their revision of the classical *Pheretima,* to assign the species to *Amynthas* which is defined as having superficial, male pores. Subsequently examined material has showed, as first reported above, that on further development the male pores are invaginated, at least into parietal chambers that on further development might even reach into the coelom.

A question that might now well be asked is: Were the specimens with superficial male pores really of the same species as those with invaginate pores? The answer is, YES. The following commonly shared, SOMATIC as well as genital characters certainly seem to require conspecificity.

Size, to 155 by 8 mm. Segments, 95-118. First dorsal pore, at 12/13. Septa, 8/9-9/10 in large part aborted. Intestinal origin, in xv. Intestinal caeca paired, arising in xxvii, manicate, length of 7-9 fingers decreasing dorsoventally. Dorsal typhlosole, simply lamelliform. Ventral typhlosole, horizontally ribbon like, with a slight median groove, in 16-17 post caecal segments. Hearts, of x lacking, of xi-xiii latero-esophageal.

Quadrithecal, pores, at 6/7-7/8. Holandric, testis sacs unpaired and ventral. Genital markings, small, circular discs closely crowded together in rather irregular transverse rows of a presetal, median patch in some of viii-xi, xix-xxii. GM glands long stalked and coelomic.

Even now, as already indicated above, a proper characterization of the ancestral, amphimictic population that was too hopefully promised in 1954 (p. 12), cannot yet be given, especially with regard to the very important male invaginations and spermathecal pores.

Obviously *hilgendorfi* does not belong in a genus defined as having superficial, *i.e., non* invaginate male pores.

Phertima houlleti (Perrier, 1872)

North American records

1887 *Perichaeta houlleti,* Beddard. Proc. Zool. Soc. London, 1887, p. 389. (Bahamas specimens only.)

1937 *Pheretima meridiana,* Gates. Bull. Mus. Comp. Zool. Harvard 80(8): 389. (After examination of Beddard's Bahamas specimens. "Diagnosis".)

1942 *Pheretima meridiana,* Gates. Amer. Midl. Nat. 27(1): 91. (In checklist of North American earthworms.)

1956 *Pheretima houlleti,* Gates. Evolution 10: 222. (Polymorphism. Parthenogenesis, expected, though not always.)

1957 *Pheretima houlleti,* Graff. Senckenbergiana 37: 115-145. (El Salvador.)

1958 *Pheretima houlleti,* Gates. Amer. Mus. Nov. No. 1888, p. 16. (Cuba.)

1960 *Pheretima houlleti,* Gates. Bull. Mus. Comp. Zool. Harvard 125:263. (Reproduction, in recently examined material, must be parthenogenetic because of male sterility.)

1972 *Pheretima houlleti,* (Hp morphs), Gates. Burmese Earthworms, p. 193-194. (New state records, Florida and Georgia, further data below.)

Material examined: **FLORIDA.** JEFFERSON CO. El Destino Plantation, 31 Jul 69, 0-0-1 (TF-610B) and 0-1-0 (TF-610A). E. V. Komarek, Sr. **GEORGIA.** WAYNE CO. Jessup, 15 Jul 69, 0-1-5 (TF-601), E. V. Komarek, Sr.

Description: Segments (also including data from recently received foreign specimens), 94, 95, 96, 97 (2), 98 (3), 99 (2), 100 (3), 101 (5), 102 (2), 103 (8), 104 (4), 105, American specimens had 100-104. Color, in dorsum, reddish brown to slate. First dorsal pore, at 9/10 (3), 10/11 (3). Setae, xviii/9, 10 (2), 11 (2), 12.

Internal anatomy: Pigment, reddish brown, in circular muscle layer. Special muscle band at mD, first recognized just behind 8/9 (a worm with first functional dorsal pore at 9/10. Hearts, of ix present on both sides but of x on the right side only (1 specimen). Anterior GM glands passed to the spermathecae internally (no externally visible markings).

Systematics

Three taxa, originally thought to be species, eventually were found to differ from each other mostly in characters of a system, the reproductive, now known to be most liable to rapid evolutionary modification. However, two of the taxa, also were distinguishable from each other by minor somatic charactera. Laboriously accumulated records of sperm maturation, and of copulatory receipt of sperm, as well as evidence for male sterility, were destroyed in Rangoon, during World War II. Subsequent replacement became impossible for the author. Facultative and obligatory parthenogenesis as well as amphimixis was variously involved. Conceivably an amphimictic population ancestral to each of the three taxa could have been differentiated into several geographical races before the appearance of parthenogenesis. Although without any precedent for the action, the three taxa were placed (Gates, 1972a: 190-195) in the synonymy of the oldest name, *i.e., houlleti.* However, anatomically definable morphs still were recognized (Gates, 1972a), even though some identifications of other authors, without adequate data for present needs, are not referable to currently indicated morphs.

Bahamas material is referable to a "larger Hp morph known only from Burma (13 districts), possibly also Nepaul. Mainland, recently secured, U.S.A. material is referable to the "smaller Hp morph". Each of those morphs is distinguishable from the other by somatic characters also. The smaller morph is also known from Cuba, (Salvador?), India, Ceylon, Burma (42 districts), Thailand, the Malay Peninsula, Singapore, Java, Manila, and the Fiji Islands. The original source of the species is thought to be somewhere in southeast Asia possibly including an eastern portion of Burma.

Pheretima hupeiensis (Miachaelsen, 1895)

North American records

1910 *"Pheretima posthuma"*, Green & Smith. (Unpublished information on a label with specimens in U.S. Natl. Mus.)

1933 *Pheretima hupeiensis,* Chen. Cont. Biol. Lab. Sci. Soc. China, (Zool.) 9: 251. (Campus of the University of Pennsylvania, Philadelphia.)

1937 *Pheretima hupeiensis,* Gates. Bull. Mus. Comp. Zool. Harvard 80: 336. (Washington, D.C. Catonsville, Maryland. First record of being a nuisance on golf greens because of castings. "Diagnosis".)

1942 *Pheretima hupeiensis,* Gates. Amer. Midl. Nat. 27(1): 91. (In checklist of North American earthworms.)

1945 *Pheretima hupeiensis,* Fleming & Bradley. J. Econ. Entomol. 38: 411. (15 gallons of worms removed at one time from a practice green of a golf course, Rye, New York, without causing a noticeable decrease in the population.)

1952 *Pheretima hupeiensis,* Causey. Proc. Arkansas Acad. Sci. 5: 31, 33. (Arkansas, two sites, two counties and an earthworm farm from which worms, presumably for bait, had been supplied to adjacent states.) Harman, Proc. Louisiana Acad Sci. 15: 22. (Common in Lincoln Parish, Louisiana.) Schread, Bull. Connecticut Agric. Exp. St. 556, pp. 1-16. (Connecticut. Habits and control of the oriental earthworm.)

1953 *Pheretima hupeiensis,* Causey. Proc. Arkansas Acad. Sci. 6: 48. (Another site from another Arkansas county.) Grant, Anat. Rec. 117: 561. (Temperature relationships.)

1954 *Pheretima hupeiensis,* Gates. Bull. Mus. Comp. Zool. 111: 234. (New York City, deer corral at Bronx Zoo. New Orleans, Louisiana.) Grant, Anat. Rec. 120; 737. (Moisture relationships.)

1955 *Pheretima hupeiensis,* Grant. Ecology 36: 400-407 (Moisture relationships.) and Ecology 36: 412-417 (Temperature relationships) Proc. U.S. Nat. Mus. 105: 49-63. (Anatomy.)

1956 *Pheretima hupeiensis,* Grant. Ecology 37: 648-658. (Ecology.)

1958 *Pheretima hupeiensis,* Gates. Amer. Mus. Nov. No. 1888, p. 17. (Greenhouses, Beltsville, Md., and Univ. of Maine, Orono, Maine. Pelham Country Club, New York. Reproduction is parthenogenetic, because of male sterility, in specimens from several sources and different periods of the year. Precis.)

1963 *Pheretima hupeiensis,* Gates. Proc. Biol. Soc. Washington 76: 13. (Kentucky, Tennessee. Greenhouses at Greenwich, Connecticut and Ithaca, New York.)

1965 *Pheretima hupeiensis,* Bhatti. Proc. Pennsylvania Acad. Sci. 39: 21, (Swarthmore, Pennsylvania.)

1967 *Pheretima hupeiensis,* Gates. Great Basin Nat. 27(3): 166. (Present at Provo, Utah, in great numbers.)

1969 *Pheretima hupeiensis,* Tandy. Thesis, Louisiana State Univ. p. 76. (Central Louisiana, 11 parishes.)

1974 *Pheretima hupeiensis,* Reynolds. Megadrilogica 1(11): 8. (Maryland, 5 counties.)

1975 *Pheretima hupeiensis,* McMahan. Trans. Amer. Micros. Soc. 94: 279-281. (*Monocystis agilis* in seminal vesicles of East Baton Rouge worms.)

1978 *Amynthas hupeiensis,* Reynolds. Megadrilogica 3(7): 123. (Tennessee, 7 counties. "Diagnosis". New state records, Florida, Georgia, Mississippi, North Carolina, Tennessee, for all except the last-named, see below.)

Material examined. **FLORIDA.** ALACHUA CO. Gainesville, 28 May 68, 2-3-0-2 (TF-528C), 1 recently hatched juvenile (TF-527B), E. V. Komarek, Sr. LEON CO., Tallahassee, 630 West Call St., 12 Aug 72, 2-0-1, D. B. Means. **GEORGIA.** CLARKE CO. Athens, dump along Oconee River, 25 Apr 67, 1-48-1-7, W. W. Baker. MURRAY CO. Oakman, 2.4 miles north, 18 Apr 68, 2-24-14-1, V. B. & W. W. Baker. PICKENS CO. Tate, 1 mile east 18 Apr 68, 10-17-0, V. B. & W. W. Baker. **KENTUCKY.** JEFFERSON CO. Louisville, Beachmont area, from a moist clay soil which abounded in crayfish holes though several miles from open water, 2 Mar 62, 0-3-0, Clifton A. Keller *per* W. R. Murchie. **LOUISIANA.** ST. CHARLES PARISH, Bonnet Carre, Spillway on Route 61, 9 Apr 62, 0-0-2 (DBM-1689), D. B. Means & J. F. Berry. ST. TAMMANY PARISH, Slidell, April 1970, 1-0-0-1 (KO-25C), E. V. Komarek, Sr. **MISSISSIPPI.** LOWNDES CO. Columbus, 1 Oct 69, 0-0-5-1 (TF-631), E. V. Komarek, Sr. **MISSOURI.** BOONE CO. north of McBaine, 7 Jun 60, (5?)-3-1, in pasture along edge of stream, upper soil moist, (5?)-3-1, W. R Murchie. **NORTH CAROLINA.** BEAUFORT CO. Bear Creek Bridge, at Route 264, 10 Jul 72, 0-6-13 (H-71A), D. Howell. DURHAM CO. South Durham, 14 Oct 69, 0-1-0 (TF-650A), E. V. Komarek, Sr. Eno River, 1.5 miles north of junction of S. R. 1634 on S. R. 1632, in deep alluvium of sand and leaves, 23 Feb 75, 0-3-13, S. W. Leonard. PITT CO. Greenville, residential area, 11 Jun 72, 2-10-0 (H-19A), D. Howell. ECU campus, 11 Jul 72, 0-0-3 (H-73F) and 0-0-1 (H-73C), D. Howell. YANCEY CO. Burnsville, 10 Oct 67, 1-3-1 (TF-279), V. B. & W. W. Baker. **TENNESSEE.** SHELBY CO. South Capleville, by creek, 17 Apr 70, 0-1-0 (TF-734), W. W. Baker. **VIRGINIA.** BUCKLINGHAM CO. Curdsville, 2 May 68, 0-1-0, V. B. & W. W. Baker. (Also specimens in the U.S. Natl. Mus., previously identified by Murchie.)

External characteristics: Segments, 123, 124, 125 (2), 126 (smallest juveniles seen), 112, 115, 119, 126 (adults from same site), Previous records (Grant, 1955), range of 119-130, average for 22 juveniles, 125, for 39 adults, 126. Prostomium, often withdrawn into the buccal cavity and then seemingly protobous, though really epilobous and with tongue open.

Male porophore rudiments are recognizable before those of the genital markings. Locations of the latter often remain uncertain. When the GM rudiments first are distinguishable, the intersegmental furrows in their vicinity already are unrecognizable. However, the markings of several immatures did seem to be just behind the levels of 17/18 and 18/19 (subsequently growing across those levels?). The only variation in number of markings noted was absence of the left anterior marking of a single specimen.

Internal anatomy: Grant's Fig. 4 (1955c) seems to indicate an intestinal origin in xiv rather than xv (were his specimens preserved in a much relaxed condition?). The typhlosole ends abruptly in the 86th (of 110), 87th (of 128), 88th (of 126), 88th (of 128) segments, leaving 24, 41, 38 and 40 respectively atyphlosolate. The supra-esophageal trunk, even when much distended with blood, was unrecognizable behind 13/14. The left extra-esophageal of one worm turned downwards and joined the subneural in xiv. A large channel at mD in the gut roof from the region of xxvi-xvii to well behind the caecal segment is often filled with blood and so protuberant from the gut that it appears to be a definite vessel just under the dorsal trunk.

Reproduction

Seminal vesicles were full of developing sperm according to Grant (1955b: 55) who presumably assumed reproduction in his worms to be amphimictic. At least, he believed the small and narrow vesicles of Chen's (1933) Chinese specimens to have shrunk during preservation (!) or to have been immature. Actually, American specimens examined by this author (1958: 19) and subsequently were male sterile and even with some of their testes feminized (though the cells that looked like ova might have been parasites).

Distribution

Taiwan. Anhwei, Chekiang, Fukien, Hupeh, Kiangsi, Kiangsu, Szechuan provinces of China, Manchukuo, Korea, Japan.

Arkansas (4 counties), Connecticut (1), District of Columbia, Florida (3), Georgia (4), Louisiana (3), Kentucky (1), Maine (1), Maryland (5), Missouri (1), Mississippi (1), New York (3), North Carolina (4), Pennsylvania (2), Tennessee (7), Utah (1), Virginia (1).

The oceanic and land gaps in the distribution just indicated, seem to require that *P. hupeiensis* was brought to the United States, *directly* from some part of the Sino-Japanese area, presumably by man, probably unwittingly, and in association with the roots of live plants that were being transported. Although the species may have originated somewhere on mainland Asia, nothing has been encountered during the search to suggest that the species came here directly from China. On the contrary, the following data do seem to favor a Japanese source:

In 1905, David Fairchild, the famous plant explorer, brought from Japan several live, Japanese, flowering-cherry trees. They were successfully acclimated at his home in Bethesda, Maryland, just outside Washington, the locale of the first American record (written but not printed unti lthe present) of *P. hupeiensis*, in 1910.

In 1909, two thousand of the very same Japanese trees were brought live to American so that the "delicate beauty" of their flowers might adorn our capital city. Some 200 of the batch were "diseased". The whole lot was destroyed.

In 1912, another two thousand were brought to Washington and were successfully established.

Five years may seem a rather short period for a species to become "common" after its introduction, at least for an earthworm.

Economic Importance

A graduate student from China, in this country to earn a doctorate was responsible for the first American record of the species to be published. (Chen, 1933). However a specimen had been preserved at Washington in 1910, by a collector who very thoughtfully had added the word "Common" to his label. By the time of the next published record (Gates, 1937: 338) the worm had already become a nuisance to one class of people. Previous treatment with mercury bichloride and lead arsenate had failed to exterminate the worms in a putting green which was "covered" on July 11, 1935, with castings deposited during the previous night; — as many as twenty were counted on a single square foot of turf". (Quotations without indication of authorship are from antiworm propaganda of the time.) Removal of two square feet of turf revealed "at least twenty specimens . . . within an inch of the surface" in spite of a maximum air temperature of 90+ degrees for several days. That may, at least in part, have been responsible for a decision by green officials to urge naming the pest "The Tropical Earthworm", (However there is no scientific record of its occurrence in the tropics, even though some golf propaganda of the time claimed its presence in Burma, India and even Africa!) Greenkeepers already had characterized it as the "stinkworm" presumably because of a disagreeable musky odor (from mutilated individuals?) that clung to the fingers. A zoologist, perhaps less annoyed or prejudiced, compared the odor (in a letter to this author) of live, uninjured worms to that of "freshly dug carrots".

The "accelerating" spread of the Tropical Earthworm" from one green to another in a golf course and from one course to another in an area extending from western Connecticut to eastern Pennsylvania, as well as a supposedly "great" increase in its activities, finally aroused angered golfers to action. Attempts were made to mobilize government zoologists, an organization was formed and funds were raised for research on the life history and methods of control of the pest. It already had come to be regarded as one of the most menacing problems on golf-course greens that had arisen for years.

Golfers problems were caused by the deposition of earthworm faeces ("granular soil masses up to 1.5 inch in diameter", heights not mentioned) on the carefully manicured green. Presumably, only golfers can appreciate the "anguish" those little piles of soil caused by delaying, preventing or interfering with the accuracy of their putting.

Such piles of castings, in appropriate conditions, could be deposited several times a day or even every two or three hours. Tramping on the castings damaged the grass and caused bare spots. Thus, play had to be delayed in the morning until castings were swept or poled. Such procedures had to be repeated several times a day and at considerable expense. The poling, itself, to some extent damaged the turf surface.

Another activity of the worms, *i.e.*, their surfacing occasionally in huge numbers seems not to have bothered golfers as much as students at Provo, Utah (Gates, 1967: 167). "Each spring and fall, and at perids of warmth . . . these worms crawled from the lawns by the thousands to sidewalks, creating quite a squishy situation for students walking back and forth from the buildings" of the Brigham Young University. Golf literature of the day does indicate that surface swarming had been observed and also that birds seemed uninterested in the phenomenon as a source of food. (So far as this author has been able to observe, birds do not eat earthworms of any species that surface-swarm during or just after rain!)

The "anguish" of a period when golfing was thought to be threatened all the way "from Connecticut to Florida" seems to have subsided. Hence it is assumed that the tropical earthworm from China is now under effective control insofar as golf courses are concerned. Unfortunately, the life history study suggested by zoologists was not made. How the worms got from one green to another and from one course to another, so very rapidly also seems not to have been determined.

Systematics

Amphimictic individuals for comparison with recently studied male sterile material of the species have not been available. The anatomical changes presumably allowed by the *hupeiensis* parthenogenesis are: Occasional deletion of a single spermatheca. Occasional deformation of a single spermathecal diverticulum. Retention of male funnels (with few plications) and seminal vesicles in a rudimentary state. Ferminization of the gonads (testes) of xi. Possibly also disappearance of knob-like spermathecal porophores on the anterior margins of vii-ix (Gates, 1937: 357) which have not been noticed recently. Location of the pores according to Reynolds (1978: 123) is at intersegmental furrows 6/7-8/9 instead of intrasegmentally in vii-ix. Reynolds (*Ibidem*, p. 123) found the testis sacs to be ventral and so unlikely to contain the seminal vesicles of xi. He also did not mention persistence and muscularization of intersegmental septa 8/9 and 9/10, which have been suspected of having some systematic importance.

Pheretima levis (Goto & Hatai, 1899)

North American records

1954 *Pheretima levis,* Davies. Breviora, No 26, p. 1-13 (New Jersey.) *P. levis* + *Pheretima* sp. II Gates, Bull. Mus. Comp. Zool. 111(6): 234 & 237. (Aquarium Building, Bronx Zoo, New York City. Reproduction probably would have to be parthenogenetic.)

1958 *Pheretima levis,* Gates. Amer. Mus. Nov. No. 1888, p. 21. (New York State, Schenectady. Seven parthenogenetic strains or morphs recognized in the U.S.)

1965 *Pheretima levis,* Bhatti. Proc. Pennsylvania Acad. Sci. 39: 21. (Pennsylvania.)

1966 *Pheretima levis,* Gates. Proc. Biol. Soc. Washington 79: 246. (Greenwich Conn., compost heap outside greenhouse.)

1978 *Metaphire levis,* Reynolds. Megadrilogica 3(7): 124. (1 site each in Marion & Hamilton Counties, Tennessee. "Diagnosis".)

Material examined: **CONNECTICUT.** FAIRFIELD CO. Greenwich, compost heap near Saxon-Krueger greenhouses, 26 Aug 57, 0-0-7 and 28 Oct 57, 0-0-19, G. G. Beckerley residence on Riversville Road, leaf piles, 10 Aug 60, 0-53-24, GEG. **FLORIDA.** SUMTER COUNTY, Dade Battlefield Memorial Park, in and around worm-bed back of superintendent's house, 14 Oct 71, 0-0-1 (RLC-93). R. L. Crawford & P. E. Jinright. **GEORGIA.** HARRIS CO. Pine Mountain, Calloway Gardens, 4 Aug 67, 0-0-4 (TF-195A) and 0-0-10 (TF-196B), B & E. V. Komarek, Sr. **NEW JERSEY.** ESSEX CO. Maplewood, leaf pile, August 53, 0-0-12. Harold Davies. **NEW YORK.** SUFFOLK CO. Mt. Sinai, 14 Nov 67, 0-0-4, M. K. Jacobson. Another Long Island collection, 26 Sep 58. 0-0-1, J. F. Cornman *per* G. E. Pickford. **NORTH CAROLINA.** PITT CO. Tranters Creek Bridge at Route 903, 25 Jun 72, 0-0-26 (H-30A), D. Howell. **PENNSYLVANIA.** DELAWARE CO. Swarthmore, Swarthmore Forest, 1962, 0-0-9, and 0-0-3, H. K. Bhatti.

External characteristics: Segments, 56; 61, 69, 71, 72, 73, 76 (2), 81, 83, 84, 85, 86, 88, 89, 90 (posterior amputees, all?), 92 (4), 93 (5), 94 (13), 95 (16), 96 (12), 97 (12), 98 (9), 99 (9), 100 (8), 101 (5), 102 (3). Prostomium, epilobous, tongue open (all). Color, red, in dorsum only. First dorsal pore, at 12/13 (all), non-functional, pore-like markings usually recognizable at 14/15 and 15/16.

Spermathecal pores, minute, superficial, two pairs about or well toward 1/2C apart, at 6/7-7/8. Male pores, minute, superficial, widely separated, each in a small porophore that always is circumscribed by a deep furrow, at eq/xviii. Genital markings, small, circular discs, each with a greyish-translucent, central area often looking like a single central pore. Preclitellar genital markings, two associated with each spermathecal pore, immediately median to the pore level, one just in front of and one just behind an intersegmental furrow. Postclitellar markings, one to three on each side in xviii, one sometimes on the male porophore, the other two just median or lateral to the male prophore.

Internal anatomy: Special longitudinal muscle band at mD, narrowing anteriorly to end at 11/12 and regardless of presence or absence of a pore-like marking at that level, distinct but unpigmented. Pigment, red, in circular muscle layer dorsally. Diagonal muscle bands have their parietal insertions as follows; those from the pharynx to iv-v, from 4/5-7/8, to two segments further back in each case, from gizzard and esophagus of ix to xi-xii, from 10/11-14/15 to xii-xvi.

Six nerves usually pass off dorsally and laterally on each side from the anterior face of the brain but with some variation as to number and also as to subsequent direction. Thus, for instance, the larger medianmost of the six on the right side almost at once divided into three branches, the lateral passing under the middle and then over the first to continue on into the prostomium. The medianmost on the left side did not so divide. From the same region of the brain but a little more ventrally, on each side, a large nerve turns downward and then back and into the pharynx. That "sympathetic nerve" may be continued some distance as a single cord or very shortly after emergence from the brain may separate into three or four variously interconnected cords. A crescentic bit of tissue on the posterior face of the brain differs slightly in its superficial appearance from the remainder of the organ and may contain neurosecretory cells as in some Lumbricidae.

The dorsal intestinal typhlosole may be lacking or rudimentary in some specimens but preservation of the intestine was poor in those worms. In better preservation it probably could be described as simply lamelliform and with vertical ridges laterally on a few of the anteriormost segments, unrecognized behind the 44th and the 45th of 83 and 85th of 90 segments, respectively leaving 39 and 50 (twice) metameres atyphlosolate. A ventral typhlosole, is a flat, ribbon-shaped band having a slight groove at mV, in the region of the 28th to 46th segments as in Table 4. This typhlosole obviously was in good condition even when the rest of the intestine was very poorly preserved.

Table 4. Location of the ventral typhlosole in *Pheretima levis.*

Segments	Specimens
28-43	1
29-41	1
29-42	2
29-43	1
29-45	1
30-40	1
30-42	3
30-43	3
30-44	4
31-44	4
31-46	1
33-46	1

Hearts, of ix on the left side only (41), on right side only (41), on both sides (2), of x lacking (all). Paired hearts at first seemed to be present in ix of two other worms but in each case, the vessel on the right (1) or the left (1) side attenuated well down in the coelom and aborted before reaching the ventral trunk.

Holandric, testis sacs, unpaired, ventral, usually well above nerve cord but including the ventral trunk or with that trunk in or on the sac roof. The sacs which are lacking in juveniles presumably are formed during adolescence even though testes do not appear and no sperm ever are produced. Seminal vesicles, in xi-xii. Pseudovesicles, only in xiii. Prostates, extending through some or all of xv-xxiii. Their ducts, 3-6 mm long, in a C- or a U-shape, an ectal portion or limb thicker. Spermathecal duct, with muscular sheen but not especially thickened, shorter than the ampulla, markedly narrowed ectal to diverticular junction at, within or close to the parietes. Diverticulum of a normal spermatheca(?) longer than the main axis, stalk with muscular sheen, usually straight though sometimes sinuous or with one or two U-shaped quirks, seminal chamber elongately ellipsoidal.

GM glands at best development, long stalked and coelomic, three associated with each spermatheca (of which one opens into the spermathecal duct within the body wall), three associated with each male porophore.

Reproduction

In the U.S. probably always parthenogenetic. Whether any amphimictic popilation still exists in its home country remains to be learned.

Distribution

Japan and in the United States, the following: Connecticut, Florida, Georgia, New Jersey, New York, North Carolina, Pennsylvania and Tennesee.

Absence from intervening areas may be due to inadequate search or because the species has not yet been introduced.

Absence of colonization elsewhere, allows a supposition that *P. levis* was brought to the U.S. directly from Japan.

Noteworthy, perhaps, in the present connection, is the absence of greenhouse and intercepted records. (Also see Reynolds, 1978: 124.) The Connecticut, greenhouse-record was of an outdoor compost heap. The compost part of the habitat is now suspected of being more important than the nearness of the heap to a greenhouse.

Ingesta

Humus. The habitat of choice in this country, seems to be decaying leaves, or any other more or less similar concentration of organic matter.

Abnormality

(Exclusive of changes in the genitalia allowed by the parthenogenesis.) No. 1. Clitellar glandularity totally lacking in a small presetal, transversely rectangular portion of xiv on the left side. No. 2. A similar lack but in an irregular longitudinal strip on the left side.

Parasites

Small cysts were present (1 worm)) in coelomic cavities from the anterior to the hind end and also in the lymph glands of the postclitellar region. Specimens were sent to a protozoologist.

Parthenogenetic Polymorphism

Too many morphs were found to list individually. Accordingly, only major deformations and degradations are mentioned.

Male terminalia. One or both prostates along with their ducts lacking. (Intermediate stages, as of a gradual decrease in size of the glands without obvious change in their ducts, as have been observed in other pheretimas, were not seen in *P. levis*.) From the material that has been available to this author, an all or non situation, on one or the other or even on both sides could be suspected. Any one, two or even all three of the post clitellar glands may be missing, and on one, or the other or on both sides. Male gonoducts, in absence of male terminalia attenuated anywhere in region of xiv-xxi or occasionally even expanded terminally into a small transparent vesicle. A gonoduct of one side of one worm even turned mesially and became adherent to the nerve cord.

Spermathecal battery. Any one, two or three organs may be lacking but with the remaining spermatheca(e) seemingly normal. Almost any one of those deletions may be combined with any of the modifications in the male-pore region. Retention of one of the preclitellar genital markings after loss of the adjacent spermatheca was found only once. Retention of a second marking by an athecal morph may be possible. However, retention of the third associated gland is not to be expected after the spermatheca is completely eliminated.

Main spermathecal aixs. The duct may be normal, the ampulla small, represented only by one or two small vesicles or entirely lacking. Duct and ampulla each may be more or less aborted. A narrowed portion of the duct ectal to the diverticular junction may be much elongated so as to bring that junction (usually just at the parietes) well into the coelom. The ampullary portion may be much elongated. The main axis ental to the diverticular junction may be deleted though the diverticulum is still normal or almost so. Diverticular axis. The seminal chamber may be shortened though still ellipsoidal, be represented by two or three small and transparent or by a single ovoidal vesicle, The diverticular stalk may be variously shortened, at times without any trace of a seminal chamber. The diverticulum may be represented only by a spheroidal knob or finally without any remaining trace. Absence of all four spermathecae (A morph) is common as also is the AR (athecal and anarsenosomphic). If the testis sacs had been checked in more specimens and with greater care, no trace of male gonads might have been common. Search for possibly hidden or vestigial testes was not made if male gonoducts were present.

Varia

Spermathecal porophores occasionally are retracted, just enough to produce an appearance of transversely slit-like secondary apertures at intersegmental furrows. The minute male pores certainly were superficial whenever present on the author's material but the circumferential furrow surrounding each discoidal porophore was so deep as to justify a question as to whether further deepening would not have resulted in the porophore being withdrawn, at least into a parietal chamber, if not with greater withdrawal into a copulatory chamber within the coelomic cavity.

The precis promised when the writer (1958, p. 24) still was hoping to see examples of an amphimictic population, is subjoined but with question marks at appropriate points. Omitted therein are the characters listed on a previous page (*i.e.*, p. 37, 40).

Precis

Quadrithecal, primary pores minute (superficial(?) or retracted, each into a parietal invagination? or even a coelomic chamber, with external apertures?) about 1/2 C apart, at 6/7-7/8. Male pores, minute, (superficial? or retracted into parietal invaginations? or copulatory chambers with transversely slit-like aperatures?) at eq/xviii. Genital markings, small, circular discs, each with a central translucence, two just median to each spermathecal pore (one just in front of and one just behind the intersegmental furrow), three to six in xviii, one on each male porophore and usually two close to the porophore. Setae, 30/iii, 45-48/viii, 47/xii, 48/xx, 50/xxx, 40/xc, 42/xciii, 40/xciv, vii/15, viii/17-20, xviii/16. Segments, 91-102. Size, to 155 by 3-7 mm.

Hearts, of x lacking. Holandric, testis sacs unpaired and ventral in x-xi. Prostates, extending through some or all of xvi-xxiii, ducts muscular, each in a hairpin loop with the ectal limb thicker. Spermathecae, with a diverticulum at least as long as the main axis, usually longer, with an ellipsoidal seminal chamber and a stalk with muscular sheen passing into the duct close to the parietes. Spermathecal ducts, with muscular sheen but not especially thickened and about as long as the ampulla. GM glands, long stalked and coelomic, one usually opening into each spermathecal duct deep in the parietes (?).

Systematics

Relationships now appear to be closest to *P. hilgendorfi* but *levis* is distinguished therefrom only by easily changed genital characters: 1) Superficial location of male pores. 2) Absence of genital markings (as well as of their long-stalked coelomic glands) in unpaired, median patches. 3) Association of three, long-stalked coelomic glands with each spermatheca and male porophore (but only two genital markings externally recognizable near each spermathecal pore).

Character three allows a suggestion that a Japanese worm which the author could not refer to any species of *Pheretima,* forty years ago (Gates, 1937a: 334), may have been of *Pheretima levis.*

The author has seen no specimens of *levis* that would allow reference of the species to *Metaphire,* a genus that is defined by withdrawal of male pores away from the exterior and into copulatory chambers.

Pheretima loveridgei, Gates, 1968

North American record

1968 *Pheretima loveridgei,* Gates. J. Nat. Hist. London 2: 257. (Type locality, Honey Lake, Madison County, Florida. Types in the British Museum and the Tall Timbers Res. Stn. Also recorded for two counties of Georgia. As all worms are male sterile, reproduction must be parthenogenetic. Systematic difficulties caused by the parthenogenesis.)

1977. *Pheretima loveridgei,* Gates. La Fauna terrestre de L'Ile de Sainte-Helene 4: 479. (Belongs in a *diffringens* species group along with *hawayana, robusta* and *morrisi* to which it seems to be most closely related.)

Material examined: **FLORIDA.** FRANKLIN CO. Carrabelle, 15 Dec 67, 0-0-1, E. V. Komarek, Jr. & Sr. LEON CO. Iamonia, 1.2 miles west, 11 Feb 67, 0-0-1, 28 Aug 67, 6-1-2, 7 Apr 68, 7-15-16 (TF-329), 29 May 68, (2?)-1-8 + 9 tails (TF-374), 29 Aug 68, 5-28-14 (TF-466), W. W. Baker. Tallahassee, Florida State University at Dewey Street, 11 Aug 71, 5-26-46 (V-30), V. Vail. MADISON CO. Honey Lake, 13 Apr 67, 1-20-34, E. V. Komarek, Sr. SUWANNEE CO. Live Oak, 5 Apr 67, 0-0-1, E. V. Komarek, Sr. **GEORGIA.** BROOKS CO. Pavo, to the east, 0.4 miles west of intersection of Routes 33 and 122, 17 Jan 72, 6-2-4 (PEJ-8), P. E. Jinright. COLQUITT CO. bridge 4.5 miles east of Mitchell-Colquitt line on Route37, 19 Jan 72, 8-1-1 (PEJ-17), P. E. Jinright. GRADY CO. Beachton, 11 Oct 69, 2-0-1 (TF-637B), 29 Mar 70, 1-0-2 (KO-1B), 3-0-2 (KO-1A), 11 Oct 69, 13-2-4 (TF-637A), 16 Aug 71, 0-0-1 (KO-96), 0-2-5 (KO-87B), 10 Aug 71, 0-0-2 (KO-94), 15 Oct 71, 0-0-1 (KO-125), 7-5-4 (KO-139), 21 Dec 71, 1-0-0 (KO-152B), 16-4-7 (KO-151A), 16 Jan 72, 0-0-1 (KO-170C), 3-5-0 (KO-171). Behind office, 29 May 72, 5-3-2 (TF-804). Birdsong Plantation, 20 Jul 69, 2-3-7 (TF-609), E. V. Komarek, Sr. THOMAS CO. Thomasville, Sedgwick, Millpond Plantation, 14 Aug 67, 0-0-4, W. W. Baker. Yard in town, 16 Aug 68, 3-2-2 (TF-461), W. W. Baker & P. E. Jinright. Jinright yard, 1 Jan 71, 0-4-5 (PEJ-1), P. E. Jinright. Greenwood Place, 2 Dec 71, 6-2-8 + tail fragments (KO-147A), 22 Dec 71, 1-4-6 (KO-46), 11-2-6 (KO-163), 3-3-1 (KO-190), E. V. Komarek, Sr. THOMAS CO. 13-5-5 (PEJ-20B), 3-1-1 (PEJ-24). P. E. Jinright. **ST. HELENA.** Under stone by Upper Gate to Broad Bottom, 4 Apr 72, 0-0-1, A. Loveridge.

External characteristics: Segments, 148 (2), 150, 152, 155, 156, 158 159 (2), all of recently hatched juveniles, 29-33 by 1 mm in size, 119, 125, 128, 131, 134, 137, 146, 150, 151, 152 (2), 154, 155(4), 156 (7), 157 (7), 158 (2), 159 (3), 160 (6), 161 (2), 163 (2), 164 (5), 165, 167, larger juveniles or early adolescents that might be mistaken for, *P. morrisi,* 160, 161 (3), 162, 165, 166, 167 (clitellates). Unamputated, fully clitellate individuals of 152-159 segments from a Greenwood site (KO-16) were no larger than 55-58 by 3 mm.

Genital markings of the St. Helena specimen were lateral to the male porophores. Spermathecal diverticula of that worm were longer than the main axis (another example of parthenogenetic hypertrophy?).

Distribution

P. loveridgei is known only from two places in the world: the South Atlantic Island of St. Helena and a small North American area that contains four Florida and four adjacent Georgia counties. Both, of course, are far from the *Pheretima* domain as delimited in Burmese Earthworms (Gates, 1972a: 149). In which section of the pheretimoid domain an amphimictic ancestral population should be sought cannot now be profitably suggested.

Autotomy

An adult of 161 segments was preserved while in the act of losing its tail. The body wall was broken through except for about one quarter of the circumference on the right side.

Regeneration

An anterior regenerate at 5/6 showed no indications of metameric differentiation or any buccal invagination. Tail regenerates, with the number of segments specified, 29 at 91/92, 22 at 107/108, 32 at 108/109, 15 at 112/113, 17 at 113/114, 12 at 125/126. Regeneration of a tail at 112/113 had resulted in resorption of some of the typhlosole which now ended abruptly in the 95th segment.

Abnormality

No. 1. Female pores, at mV in xiv and xv. Left side, normal. Right side: Spermathecal pores at 6/7-7/8. Clitellum in xiv-xvii. Male pore in xix. Testis sacs in xi-xii. Seminal vesicles in xii-xiii. Ovary in xiv. Last heart in xiv. Intestinal origin in xvi. Intestinal caecum arising in xxviii. No. 2. Right side: Male pores in xv and xvi, each with its own prostate that has a well developed duct, the male gonoducts passing to the anterior prostatic duct. Right intestinal caecum arising several segments in front of that on the left side because of metameric anomalies behind xviii. Left side, gonad of xi an ovotestis. No. 3. Spermathecae of vii lacking (an American worm). Right male porophore small, that of the left side lacking as were the prostates (of both sides along with their ducts and the postclitellar genital markings.

Systematics

P. loveridgei and *P. morrisi* were found together, for the first time, at certain Thomas County sites. The two species were easily distinguished from each other by the number of segments and the more marked protuberance of the male pore region in the case of *loveridgei.* Even tail pieces could be distinguished by typhlosolar characteristics. During his study of the earthworms of Burma and China, this author began to think that a start on pheretimoid species-clustering, could well begin with a *diffringens* species-group containing that taxon along with *hawayana, morrisi, robusta* and probably *aspergillum. P. loveridgei,* sometimes mistaken for *morrisi* and also with simple, intestinal caeca, of course would later have been added.

Pheretima minima (Horst, 1893)

North American records

1969 *Phereima minima,* Tandy. Thesis, Louisiana State Univ., p. 81. (23 specimens from 10 sites of 5 parishes in southern Louisiana. Each worm was secured in a man-influenced site, botanical garden, flower bed, nursery, park, etc.)

1972 *Pheretima minima,* Gates. Burmese Earthworms, p. 206. (New state records, Alabama, Florida, Georgia, Mississippi, South Carolina, Virginiana. Locality data below.)

1961 *Pheretima minima,* Gates. Zool. Meded Leiden 37(18): 279. (Complete synonymy to date. Description of 4 specimens from Hawaii. Differences from other bithecal pheretimas with spermathecal pores at 5/6. *P. ishikawai* Ohfuchi, 1941 and several Chinese species not definitely distinguishable. Reproduction, presumably parthenogenetic.)

Material examined: **ALABAMA.** COVINGTON CO. Wing, Conecuh National Forest, 5 Apr 70, 3-0-1 (KO-7B), E. V. Komarek, Sr. MOBILE CO. Alabama Port, 8 Apr 70, 0-0-1 (KO-25B), E. V. Komarek, Sr. **FLORIDA.** ALACHUA CO. Gainesville, 28 Mar 68, 0-7-7 (527B), E. V. Komarek, Sr. LEON CO. One mile east of Tall Timbers, 18 Dec 66, 1-1-12, W. W. Baker. Tallahassee, campus of Florida State Univ., at Dewey Street, 11 Aug 71, 0-0-1 (V-31), 1-0-14 (V-32), V. Vail. Tall Timbers Research Station, 24 Dec 71, 0-0-2 (KO-157B), 0-0-1 (KO-156A), E. V. Komarek, Sr. MADISON CO. Honey Lake, 6 May 66, 0-0-1, 10 Nov 66, 0-0-21, 13 Apr 67, 1-4-6, E. V. Komarek, Sr. WALTON CO. Freeport, to the south, 14 Jul 59, 0-0-1, W. R. Murchie. Choctawatchee River, at Route 20, 14 Jul 59, 0-0-1, W. R. Murchie. **GEORGIA.** BERRIEN CO. Adel, to the east at New River Bridge, 18 Jan 72, 0-0-5 (PEJ-12C), P. E. Jinright. COLQUITT CO. Bridge, 4.5 miles east of Mitchell-Colquitt line on Route 37, 19 Jan 72, 2-1-8 (PEJ-17), P. E. Jinright. COOK CO. Adel, 1.5 miles east on Route 37, 18 Jan 72, 3-5-34 (PEJ-11), P. E. Jinright. GRADY CO. Beachton, Birdsong Plantation, base of bird bath, 28 Apr 68, 2-1-7 (TF-556B), 1-1-3 (TF-556A), 17 Apr 67, 3-4-2 (TF-26), 5 May 68, 0-0-1 (TF-558B), 11 Apr 70, 0-1-0 (KO-34B), 11 Oct 69, 0-0-2 (TF-637A), 15 Oct 71, 0-0-1 (KO-127), 16 Oct 71, 0-11-51 (KO-132), 21 Dec 71, 0-0-1 (KO-145), 0-6-51 (KO-152A), 24 Dec 71, 0-0-3 (KO-153B), 14 Jan 72, 0-0-1 (KO-169), 16 Jan 72, 0-0-1 (KO-170A), 18 Jan 72, 0-0-1 (KO-173D), 1 Feb 72, 0-2-0 (KO-186C), 2 Feb 72, 0-0-1 (KO-200), 4 Feb 72, 0-1-0 (KO-187). E. V. Komarek, Sr. LOWNDES CO. 1-0-7 (PEJ-10A), P. E. Jinright. MITCHELL CO. Cotton, 2.8 miles west on Route 93, 19 Jan 72, 0-4-13 (PEJ-16A), P. E. Jinright. THOMAS CO. Sedgwicks, millpond plant, 14 Aug 67, 0-10-40, W. W. Baker, Thomasville, yard in town, 16 Aug, 0-01 (TF-461), W. W. Baker & P. E. Jinright. Greenwood Place, 22 Dec 71, 0-0-1 (KO-163), P. E. Jinright. Metcalf, 2 Feb 72, 0-0-9 (KO-195), 0-2-11 (KO-190), 0-3-4 (KO-192), 0-0-3 (KO-191), E. V. Komarek, Sr. 0-5-2 (PEJ-20C), P. E. Jinright. 22 Dec 72, 0-1-0 (KO-147B), 0-2-8 (KO-149B), E. V. Komarek, Sr. WAYNE CO. Screven at Route 24, 17 Aug 63, 0-0-1, W. R. Murchie. **MISSISSIPPI.** PEARL RIVER CO. Poplarville, 12 miles south on Route 11, 24 Mar 71, 0-0-3 (TF-755), R. L. Crawford & D. B. Means. **SOUTH CAROLINA.** ORANGEBURG CO. Orangeburg, 12 Oct 69, 0-0-1, with spermathecae and large prostates (TF-641B), E. V. Komarek, Sr. **VIRGINIA.** PRINCE EDWARD CO. Farmville, 16 Oct 69, 0-0-2 (TF-651), E. V. Komarek, Sr. (Also examined were nearly 50 specimens from Hawaii.)

External characteristics: Size (contracted), 25-56 by 1.5-2 mm. Segments, 56, 73, 76 (2) posterior amputees, 77 (2), 78 (3), 79 (2), 80 (10), 81 (2), 82, 83 (3), 84 (4), 85 (4), 86 (5), 87 (2), 88 (2), 89 (7), 90 (4), 91 (3), 92 (2), 93 (2), 95, 96, 97 (2), 98, 99 (2), 110, 115.

Clitellum, occasionally reaching slightly into xvii (with dorsal pore at 16/17 occluded), intersegmental furrows, dorsal pores and setae (usually) unrecognizable, 4 setae present ventrally in xvi (1). Male pores, minute superficial, each may be within a small, equatorial tubercle (sometimes unrecognizable) within but distinctly demarcated by a furrow from a larger area of slight epidermal modification that may reach to or even slightly dislocate 17/18 and 18/19. Shape of the larger area, when recognizable varies from nearly circular to elliptical and then may be longitudinally or transversely placed. Although such porophores are not closely paired, setae usually are lacking between them, on one exceptional worm 12 setae were counted. Numbers of setae in xvii and xix between male pore levels, 7-11.

Internal anatomy: Septa, 8/9-9/10 lacking (or merely unrecognized because destroyed in pinning out the worms?) Pigment, none in the parietes.

Typhlosole, present from xxvii, simply lamelliform, fairly high relative to thickness of body, ending abruptly in region of the 48th to 76th segments leaving 22-38 metameres atyphlosolate (*cf.* Table 5). Hearts, in viii with unaborted dorsal portions passing to the gizzard, in ix on the right side (1), the left side (1) or both sides (2), in x not found perhaps because they were empty, or present on both sides (2), the last pair in xiii (7).

Table 5. Typhlosole termination and segment number in *Pheretima minima.*

Segment in which typhlosole ends	Atyphlosolate segments	Total number of segments
57	6	64 pa
80	15	95 pa
48	38	86
55	30	85
59	25	84
60	30	90
64	28	92
68	22	90
72	22	94
76	23	89

pa posterior amputee

Prostates, large, multilobed, each lobe almost discrete, in some or all of xvi-xxiii. Their ducts, 1.5-2 mm long, shortly u-shaped, slightly muscular and then usually of about the same thickness throughout, or J-shaped, with marked muscular sheen, gradually widening ectally. GM glands coelomic, composite, several stalks distinguishable, occasionally one of a bundle emerging from the body wall separately.

Ovaries, fan-shaped, with numerous, short egg strings.

Reproduction

Male funnels, though small usually were still plicate. Testes, unrecognized. Seminal vesicles, small to mere vestiges. Prostates and their ducts as well as spermathecae usually were lacking. Iridescence was lacking on male funnels and in male gonoducts as were sperm in seminal vesicles of worms with clitellum at maximal tumescence. Spermathecae, genital markings and their glands also were absent usually. Such worms obviously were male sterile, as were an occasional individual with a really well developed prostate or a spermatheca but usually abnormal. Reproduction accordingly must be parthenogenetic.

Tandy (1969) did find sperm in the spermathecae of one worm and believed (p. 84) that reproduction was normally amphimictic on Avery Island of Iberia Parish, Louisiana. However, only four of his Avery worms had spermathecae. The others being unable to receive sperm in a copulatory act, presumably had to reproduce parthenogenetically.

Distribution

Buitenzorg and Tjibodas, Java, in the *Pheretima* domain as delimited by the author (1972a: 202). Elsewhere: Rangoon (one plant pot of a Kokine residence), Burma. China, Queensland, Australia. Oahu Island, Hawaii, Alabama (2 counties), Florida (4 counties), Georgia (8 counties), Mississippi (1 county), South Carolina (1 county), Virginia (1 county).

Regeneration

In spite of a liability to autotomy, tail regeneration was recognized just once in the present collections, and then on an already autotomized fragment. However, from fewer specimens, Tandy (1969) found regenerates of 15 segments at 57/58, of 9 at 59/60 and of 10 at 66/67.

Autotomy

Many worms lacked some portion of the posterior end. The evidence for autotomy is as follows: 1) Amputation in each case was exactly at an intersegmental furrow. 2) If pieceshad been torn off by a reptile, bird or other predator, the amputation pesumably would not have always been at an intersegmental furrow. 3) Initially only rupture of the body wall was involved, without tearing the gut. 4) Incomplete instances of body wall rupture showed no evidence of predator action. Partial body-wall ruptures were at least a little more than one quarter of the circumference, but could be as much as one half to three quarters of the circumference.

Single autotomy was noted at the following levels: 39/40, 43/44 (2 specimens), 45/46, 47/48, 49/50, 51/52, 52/53 (2), 53/54 (2), 55/56 (2), 66/67. Double autotomies were at: 40/41 and 51/52, 42/43 and 47/48, 43/44 and 50/51. The last worm, of 75 segments, had completed the posterior amputation but the anterior (at 43/44) was incomplete, although the body wall was ruptured all around the circumference the gut still was unbroken. The gut still was unsevered in region of 61/62 of a 76 segment worm. Other uncompleted autotomies were noticed, including one at 69/70 of an 82 segment worm. Autotomy at 57/58 had been followed by a marked constriction at 56/57 that might have been followed by a second autotomy had not the worm been preserved. With as slight a pull as was possible for him, the author attempted completion on preserved worms. The edges thus artificially separated obviously were frayed or jagged, not smooth as on the remainder of the circumference.

Abnormality

No. 1. A long helicometamere in middle of the intestinal portion of the body. No. 2. Right male pore and right half of the clitellum one segment in front of the normal locations on left side. A spiral anomaly beginning with xi was unrecognizable on the right side. No. 3. Left side, clitellum is in xiii-xviii, a male porophore, prostate and duct are lacking. The right side is normal.

Parasites

Numerous cysts of various sizes and shapes were present on the body wall of one specimen that was sent to Dr. Puytorac. Unusually large cysts (relative to size of the host) were present on the body wall of another worm on the right side of xi, the left sides of xi and xvii, with two more in the anal region. Eighty-one cysts, each about $^{3}/_{4}$ mm thick were on the coelomic side of the body wall in vi-lxxx of a Leon County worm.

Parthenogenetic Polymorphism

Precise listing of each morph seems unnecessary, in view of the fact that almost every specimen examined carefully seems to be more or less different from all others. Major modifications recognized hitherto are in the spermathecal battery and the male terminalia. How the normal pattern of GM locations should be characterized is unknown.

Bithecal morphs. Both spermathecae rudimentary (2). Each spermatheca bifid nearly down to the parietes, each half diverticulate, much elongated so as to reach behind the gizzard and be coiled up in front of 10/11 (1). Spermatheca also hypertrophied but confined to vi (2), or passing into v (2). Three genital markings in vi, one median to each spermathecal pore and one at mV (9). Similar markings were on xiv-xx (1), xix and xxi (1), xx (2), xx and xxi (2), xxi (1). GM glands of those morphs varied from those reaching well into the coelom with unusually long stalks (perhaps hypertrophied) to mere stalkless bits of tissue flattened against the body wall.

Monothecal morphs. Spermatheca on the right side, in two nearly equisized portions, each without any indication of differentiation into main axis and diverticulum. Spermatheca on the left side, its diverticulum represented by small subspheroidal knob.

Athecal morphs often lacked preclitellar genital markings though two had a postclitellar marking each, in xx or xxi.

Morphs with modified male terminalia. A prostate lacking on either side but both prostatic ducts present (4). Prostates present but rather ribbon-shaped and with the ducts from their anterior ends (several specimens).

Seminal vesicles, when not rudimentary in some of the morphs were compactly filled with a brownish debris, apparently of the same material that constitutes the coelomic brown bodies of earthworms.

Systematics

P. minima according to Sims & Easton (1972) is in *Amynthas*. This author long has suspected that the species could go in a *diffringens* species group, when an amphimictic population is found.

Pheretima morrisi (Beddard, 1892)

American records

1937 *Pheretima morrisi*, Gates. Bull. Mus. Comp. Zool. Harvard 80(8): 361. (Louisiana, Texas. The supposed Mississippi occurrence is a *lapsus calami* as is obvious from the footnote at bottom of p. 363.)

1942 *Pheretima morrisi* Gates. Midl. Nat. 27(1): 91. (In checklist of North American earthworms.)

1954 *Pheretima morrisi*, Gates. Bull. Mus. Comp. Zool. Harvard 111(6): 238. (Vassar College greenhouses, Poughkeepsie, New York and Lutz, Florida. Lutz worms were from beds of a bait dealer who was raising worms for sale.)

1958 *Pheretima morrisi*, Gates. Amer. Mus. Nov. No. 1888, p. 31. (In key to North American species of the genus.)

1963 *Pheretima morrisi*, Gates. Proc. Biol. Soc. Washington 76: 14. (Greenhouses, Bangor, Maine.)

1966 *Pheretima morrisi*, Gates. Proc. Biol. Soc. Washington 79: 246. (Greenhouses, Flint College, Genessee County, Michigan.)

1968 *Pheretima morrisi*, Gates. J. Nat. Hist. London 2: 253. (Florida (3 counties), Georgia (1), Texas (2). Egypt, Pakistan.

1969 *Pheretima morrisi*, Tandy. Thesis, Louisiana State Univ. p. 86. (23 parishes in Louisiana.)

1972 *Pheretima morrisi*, Gates. Burmese Earthworms, p. 202. (New state records, Alabama, Georgia and Mississippi, further data below.)

Material examined: **ALABAMA.** BARBOUR CO. Clayton, 11 Jul 69, 0-1-2 (TC-62A), 0-1-4 (TC-62B), 0-0-1 (TC-62C), E. V. Komarek, Sr. HOUSTON CO. Dotham, 11 Jul 69, 0-1-4 (TC-63), E. V. Komarek, Sr. MONTGOMERY CO. Montgomery, 10 Jul 69, 0-0-2 (TC-60), E. V. Komarek, Sr. **FLORIDA.** ALACHUA CO. Gainesville, 28 Mar 68, 0-0-1, E. V. Komarek, Sr. GULF CO. Weewahitchka, 10 May 69, 0-0-2 (TC-50A), 0-0-3 (TC-50B), E. V. Komarek, Sr. JEFFERSON CO. Monticello, 5 Apr 67, 0-1-83-7, E. V. Komarek, Sr. PALM BEACH CO. South Okeelanta, 4 Jul 68, 9-13-35 (TF-409), 0-0-2 (TF-410), W. W. Wilson & P. E. Jinright. VOLUSIA CO. Daytona Beach, 1 May 67, 0-0-2 (TF-502A), 1-1-15 (TF-502B), 12 Aug 67, (6?)-1-0 and 0-0-3, (TF-507), 23 Mar 68, 1-0-5 (TF-523), 10 May 68, 0-3-1, 12 Jun 68, 0-0-6, (TF-571), Allandale, 28 Dec 67, 0-0-3, 27 Jun 68, 0-0-4 (TF-573), 27 Jun 68, 0-0-2 (TF-574), 2-1-0 (TF-572), W. Wetherill. **GEORGIA.** DOUGHERTY CO. Albany, 2.8 miles west, 8 Oct 67, 0-1-3 (TF-273), V. B. & W. W. Baker. GRADY CO. Beachton, Birdsong Plantation, 15 Oct 71, 0-0-2 (KO-126), E. V. Komarek, Sr. THOMAS CO. Thomasville, low area of hard wood in city limits, 10 Mar 67, 0-0-1, E. V. Komarek, Sr. Thomasville, Sedgwick's, millpond plant, 14 Aug 67, 0-1-8, W. W. Wilson. **LOUISIANA.** ST. CHARLES PARISH, Bonnet Carre, Spillway on Route 1, 9 Apr 72, 0-0-2 (DBM-1689), D. B. Means & J. F. Berry. **MISSISSIPPI.** PEARL RIVER CO. Poplarville, 29 Mar 71, 0-0-2 (TF-754), 12 miles south on Route 11, 24 Mar 71, 0-0-1 (TF-755), R. L. Crawford & D. B. Means. **TEXAS.** BROWN CO. Brownwood, 11 Aug 68, 1-1-9 (TF-444), 0-0-1 (TF-445), W. W. Baker & P. E. Jinright.

SINGAPORE. University of Malaya premises, 0-0-1. Batu Barendam, 23 May 61, 0-0-5. Taiping, 24 Apr 61, 0-0-5, C. H. Fernando. Singapore Island, 17 Jul 62, 0-0-1, 17 September, 0-0-1, 26 September, 0-0-1, December 28, 0-1-0, 3 Jan 62, 0-0-1, W. C. Chia. MALAY PENINSULA. Malaca, 20 Feb 63, 0-0-1. Kuala Lumpur, 11 Mar 62, 0-0-1, W. C. Chia.

Interceptions: **GUATEMALA.** From one quarter pound of earth with orchidaceae in baggage on plane arriving at San Pedro, 31 Mar 52, 0-0-1. **MADEIRA.** From earth with rose bush arriving at Logan airport, Boston, 29 Aug 49, 0-0-1. **ITALY.** From earth with asparagus fern, in baggage on Christoforo Colombo, arriving at New York, 24 Jul 54, 0-3-0. From earth with Begonia plant in baggage on Andrea Doria, arriving at New York, 23 Oct 54, 0-0-1. **MEXICO.** From earth with assorted plants arriving at Gateway Bridge, Brownsville Texas, 23 Mar 50, 0-0-3. From earth with palm arriving at Brownsville, Texas, 26 Nov 52, 0-0-1. From earth with fern in baggage arriving at Nogales, 24 Jan 65, 0-1-0. From earth with *Euphorbia pulcherrima* from Guadalajuara, Jalisco, in baggage on auto arriving at Tucson, Arizona, 15 Dec 65, 0-0-1. **SPAIN.** From earth with *Pelargonium* plant, in passengers baggage, arriving on the Rosa at New York, 26 Nov 54, 0-0-1. From earth with *Wisteria* plant in baggage on the United States arriving at New York, 9 May 55, 0-0-2.

External characteristics: Segments, 76, 78, 79, 85 (posterior amputees), 81, 82, 84 (each with metameric differentiation incomplete and anus dorsoterminal even though clitella are fully developed), 85, 97, 88 (2), 89 (4), 90, 91 (4), 92 (5), 93 (10), 94 (13), 95 (12), 96 (7), 97 (3), 98, 99 (2). First dorsal pore, at 10/11 (22).

Male porophores, much smaller than the closely associated genital markings and often withdrawn into a slight depression. Then sometimes covered over by a slight lateral fold. A small area of the body on each side which contains several concentric furrows, the male porophore and the two associated genital markings is markedly protuberant in relaxed individuals.

Genital markings (excluding the almost invariable pair closely associated with each male porophore) are presetal. A series of unpaired medians in v-ix was found once, 10-13 markings were present in the region of xvii-xix on 5 specimens. Number of preclitellar markings varied from 3 to 15. Any marking in either of the three positions (*i.e.* at mV, lateral or just median to spermathecal pore levels) may be doubled or, very rarely tripled.

Internal anatomy: Typhlosole, lacking or so rudimentary that presence or absence in an anterior portion of the intestine is uncertain, represented more posteriorly through 11-18 segmenta by a segmentally interrupted, flat band associated with paired diagonal and posteroventrally running ridges passing through two consecutive segments. In worms of 77-79 segments the bands are located in regions beginning with the 46th to 51st segments and ending in the 58th to 67th.

Testis sacs are obviously paired in several of the present worms. A gland associated with a median marking obviously is composite as separated portions may be seen on each side of the nerve cord. Such glandular masses are not noticeably larger than those with an undivided stalk passing to lateral markings.

Reproduction

No reason has been found for suspecting that anything except amphimixis is involved.

Distribution

P. morrisi had not been reported previously from Guatemala, Italy, Madeira, Mexico and Spain. Yet each of those countries was listed by this author (Gates, 1972a: 203) as having the species. Solely because of his identification of worms intercepted by inspectors of the U.S. Bureau of Plant Quarantine as shown above. The prospective immigrants were secured during a routine examination of earth protecting the roots of entering plants. *P. morrisi* accordingly must have been present in each of those five countries in a greenhouse, nursery, botanical garden or other institution, perhaps even in care of any of various individuals interested in the propagation of living plants. Escape of megadriles, along with discarded, exhausted earth and various plant debris, must often take place. If some favorable natural habitat is reached, acquisition of domicile should be possible in each of those five countries.

P. morrisi, like *P. californica* and *hawayana*, is originally from a temperate zone, Chinese portion of the *Pheretima* domain. (Tandy found the species in 23 Louisiana parishes). Do the new records for Alabama, Florida, Georgia and Texas, indicate the species is spreading in the southern states? Or are we learning what should have been known long ago?

Regeneration

Tail regenerates: Of 15 segments at 65/66, of 12 at 67/68, of 11 at 73/74, of 10 at 58/59, of 9 at 61/62, 68/69 and 76/77, of 8 at 67/68 and 77/78, of 7 at 70/71, 71/72, 79/80 and 82/83, of 6 at 76/77 and 81/82, of 3 at 91/92. A large metamerically undifferentiated periproct had been formed after amputation at 38/39 (1) and 81/82 (1). As many as 37.5% of a single series had natural posterior regenerates.

Abnormality

No. 1. A worm of 84 segments had a spiral metamerism involving iii-iv only, other metamerism was normal externally. Intestinal caeca arose in xxiv. Textis sacs were paired and widely separated. Iridescence on male funnels and in the spermathecae showed that sperm had been matured and exchanged during copulation. Left side; male porophores in xvii, xviii, xix, each was associated with the usual pair of genital markings as well as a fair-sized prostate along with a well-developed duct. The male gonoducts joined the most anterior prostatic duct. Right side; septum 13/14 lacking, female funnel on the septum at 14/15 along with the last heart, both one segment behind their equivalent on the left side.

Varia

Careful search throughout much of Burma between World Wars I and II, found *P. morrisi* in the tropical portion of the country only at Mt. Popa and on the Shan Plateau. North of the tropic only was it found in the lowlands. Identifying it from the Malay Peninsula was surprising. But is the species permanently domiciled there?

Systematics

P. morrisi, according to Sims & Easton (1972), is in a *morrisi* species group of *Amynthas*, The writer long thought relationships are closer with *P. diffringens* and *hawayana*. With the latter species *morrisi* has been confused.

Pheretima posthuma (Vaillant, 1868)

North American records

1887 *Perichaeta affinis*, Beddard. Proc. Zool. Soc. London 1887, p. 389. (Bahamas.)

1937 *Pheretima posthuma*, Gates. Bull. Mus. Comp. Zool. Harvard 80(8): 363. (As this species had been confused in the states with *P. hupeiensis*, confirmation of the Bahamas record was desired. Unfortunately, Beddards specimens could not be found in the British Museum and probably are not extant. "Diagnosis".)

1958 *Pheretima posthuma*, Gates. Amer. Mus. Nov. No. 1888, p. 31. (In key to North American species of the genus.)

1972 *Pheretima posthuma*, Gates. Burmese Earthworms, p. 212. (New state record, Florida, further data below.)

Material examined: **FLORIDA.** BROWARD CO. Fort Lauderdale, 16 miles to the northeast in sow-grass muck, 15 Sep 71, 3-4-18 (KO-103), E. V. Komarek, Sr. COLLIER CO. E Ochopee, 3 Jul 68, 2-0-0 (TF-402), W. W. Baker & P. E. Jinright. DADE CO. Homestead, hard, sticky clay of canal bank and along a shrub nursery, 19 Jan 67, 3-0-8 (TF-506A,B). Gould's, 6 Dec 67, 6-19-70, (TF-506A,B), 28 Aug 73, 0-17-20 (KO-219A) and 0-5-8 (KO-219B) and 0-1-3 (KO-220), 15 Aug 74, 0-1-0 (KO-228), E. V. Komarek, Sr. Homestead, 3 Jul 68, 59-14-27 (TF-406). W. W. Wilson & P. E. Jinright. Princeton, 15 Sep 71, 0-6-6-2 (KO-106). West Miami, 14 Aug 74, 0-0-1 (KO-226) and 2-24-8 (KO-233), E. V. Komarek, Sr.

External characteristics: Segments (including 8 from Pakistan), 68, 78, 89, 93, 99 (3), 100, 101 (all posterior amputees), 107, 109, 110, 112 (4), 113 (10), 114 (20), 115 (16), 116 (14), 117 (2), 118. Segment i with numerous rugosities which together with a marked weakness of the anterior margin of the segment makes recognition of a prostomium difficult. First dorsal pore, at 11/12 (1), 12/13 (34), in several of the latter, a small, black-appearing, more or less pore-like but obviously non-functional marking was discernible at 11/12. Female pore, median, except on one worm that had a pair of pores (a reversion to a long lost ancestral condition!).

Internal anatomy: Longitudinal muscle band at mD, first recognizable just behind 11/12. Intestinal caeca, often turned upwards in xxvi. Typhlosole, ending abruptly in 85th to 95th segments (usually in the 88th to 90th of 49 specimens), leaving 20-28 metameres (usually 24-26 of 49 specimens) atyphlosolate (Table 6).

Table 6. Typhlosole termination and segment number in *P. posthuma*.

Segment in which typhlosole ends	Atyphlosolate segments	Total number of segments
57	11	68 pa[1]
67	11	99 pa
72	17	89 pa
75	24	99 pa
71-77[3]	1	78 pa
80	19	99 pa
80-81[3]	12	93 pa
85	16	101 pa
85	24	109
85	27	112
86	21	107
86	24	110
86	26	112 (2)[2]
88	12	110 pa?
88	25	113 (7)
88	26	114 (2)
88	28	116
89	23	112
89	24	113
89	25	114 (10)
89	26	115 (2)
89	27	116
90	23	113 (2)
90	24	114 (5)
90	25	115 (11)
90	26	116 (2)
90	27	117 (2)
91	23	114 (2)
91	25	116 (3)
91	26	117
92	23	115 (2)
92	24	116 (3)
92	25	117
92	26	118
93	22	117
93	23	116 (2)
95	20	115

[1]pa posterior amputee

[2](2) and (7), etc., number of specimens

[3]71-77 and 80-81 typhlosole partially resorbed after the posterior end was amputated

Reproduction

Probably usually amphimictic in Indo-Burmese populations as sperm are matured and then exchanged during copulation. Abnormalities of sorts often associated with parthenogenesis did lead this author to suspect that some philippine specimens may have been parthenogenetic.

Distribution

Florida, three of the southernmost counties, the nearby Bahamas, and Argentina are the only places in the American hemisphere where the species has been recognized.

In India it is common, seemingly everywhere, in lowlands of the Indo-Gangetic plains as well as the northern parts of the peninsula. In Burma also common in lowlands to 2500 feet, in 32 districts from the southern boundary in the Malay Peninsula to Homalin, Myitkyina and Bhamo in the far north. In India, the species certainlyis exotic. In Burma, in spite of its large range and presence along hundreds of miles of river banks in numbers that must reach billions, it also is exotic though now within part of the pheretimoid domain. Indeed, its only close relatives now appear to be, *P. fluvialis* Gates, 1939, known only from the original description of several Thailand specimens and *P. juliani* Perrier, 1875, known only from the description of five specimens, collected at Saigon, Vietnam.

Elsewhere: Amboine, Anadaman Islands, Bahamas, Celebes, Christmas Is., Egypt, Flores, Formosa, France, Groot Bastaard, Java, New Hebrides, Nias, Philiipines, Santa Cruz, Sebesi, Sumatra, Sumba, Ternate, Tinian.

Michaelsen (1931, Peking Nat. Hist. Bull. 5 (3): 2) cites Stephenson (1912, Rec. Indian Mus. 7:273-278 for the occurence of *P. posthuma* at Tengyueh, Yunnan Province, China. Stephenson's record is "Ye-nan-Gyaung, Magwe, N. Shan States, Upper Burma". Neither of the two mentioned localities is in the Northern Shan States. There was no record for Yunnan.

Variation

None has been found with reference to two aspects of the GM location pattern; Equatorial intrasegmental position and location behind xiv. Divergences from the standard pattern (except of course when abnormality is involved) are of three classes: (A) Absence of one or more of the four markings. Examples from present specimens; absence on right side of xvii (2 specimens), on left side of xix (3). (B) Additional markings present. Examples, also from present specimens; right side of xx (1 specimen), left side of xxv (1), left side of xxvi (1). (C) One or more of the usual markings lacking but extra markings also present. Examples: Lacking on left xix, present on left xvi (3). Lacking in both sides of xvii, present in left xx (1). Lacking in xix, present in right xvi (1). Lacking in right xix, present in xvi (1) or right xxiv (1). Each of the 54 specimens secured at Gould's lacked variation in the GM pattern.

Abnormality

No. 1. Spiral metamerism involving ii-iii. No. 2. Left male porophore superficial, circular, about size of central areas of the genital markings, distinctly delimited by a circumferential furrow but without any trace of the usual invagination. Left male gonoduct passes into parietes of xviii directly without intervention of a prostate gland and its duct, no vestiges of which were found.

No. 3. Male pores in xv. Genital markings, left and right sides of xvi, left side only of xvii. A spiral metamerism, recognizable only on the right side and dorsum forced counting of segments on the left side. Spermathecal pores at 4/5-5/6. The anterior abnormality may be due to hypomeric regeneration at or slightly in front of 7/8 (?).

Varia

Pheretima posthuma is THE earthworm to most Indian students, just as *Lumbricus terrestris* is often spoken of by Europeans and Americans as THE Earthworm. The author's ire has been stimulated on various occasions by use of "THE EARTHWORM" without a taxon name as if there were only one megadrile species. Even more annoying has been "The earthworm, *Lumbricus terrestris*" in scientific papers when another species was involved.

The late R. E. Tandy searched very thoroughly throughout the entire state of Louisiana for *P. posthuma*. But in vain. Accordingly he was really pleased to be able to report to this author (*in litt*) presence of the species in Florida. Tandy's report enabled the first record of the species for the United States. Where his specimens were obtained is unknown as none of his work was published.

Pheretima affinis, Darwin, 1881. The Formation of Vegetable Mould through Action of worms with Observations on their Habits, London, p. 106 and Fig. 2. Darwin's Fig. 2, of a typically "tower-like casting from near Nice", France. A Dr. King gave Darwin some earthworms collected near Nice that he believed had "constructed" such castings. The worms were identified by Perrier as *Perichaeta affinis* (a synonym of *P. posthuma*), *P. luzonica* (a synonym of *Lampita mauritii*) and *P. houlleti*. Castings of each of those three species were studied in Burma and in India (*cf.* Gates 1972a: 214). Both in the author's lab and in nature, castings of *mauritii* and *posthuma* never were tower-like. Is *posthuma* present in France?

Systematics

P. posthuma, according to Sims & Easton (1972) goes into a *posthuma* species complex of *Metaphire*. That genus, except for presence of intestinal caeca in xxvii and of copulatory pouches, is defined by characters qualified by the following words: "rarely" (4 times), "or" (five times), "usually", "seldom", "often", "occasionally" (once each). Attention already has been called to the lack of precision in characterization of those chambers into which male pores are withdrawn from the surface. One example shows some of the difficulties involved. *P. tschiliensis* is referred to a *sieboldi* species group in *Amynthas* (without copulatory chambers in spite of the fact that its pores are withdrawn into spaces much larger than those in the chambers of *P. anomala, californica* and *posthuma*, each of which is allotted to *Metaphire*. Male pore invaginations of *P. posthuma* actually may represent an early stage in a kind of development that has terminated in the *tschiliensis* chambers, although that does not mean both species are in the same line of descent.

Pheretima robusta (Perrier, 1872)

American references

1937 *Pheretima robusta*, Gates. Bull. Mus. Comp. Zool. Harvard 80 (8): 364. ("West Indies".)

1942 *Pheretima robusta*, Gates. Amer. Midl. Nat. 27(1): 91. (In checklist of North American earthworms.)

1958 *Pheretima robusta*, Gates. Amer. Mus. Nov. No. 1888: 31. (In key to American species of the genus.)

The single American record of this taxon, "West Indies", may have been mistaken. Presence in this hemisphere has not been confirmed. Types were secured in the Indian Ocean Island of Mauritius and at Manila (Philippines). Which means that transportation must have been involved. If not as usual by man, at least by

some other agent. During the last fifty years, the species never was intercepted at American ports of entry, by inspectors of the U.S. Bureau of Plant Quarantine.

The author occasionally saw some spermatozoal iridescence on male funnels but only once recorded it, presumably after copulation with another individual, in spermathecal, seminal chambers. Male sterility often required reproduction to be uniparental. An amphimictic population never has been recognized as such. Indeed, how it is likely to be characterized now seems doubtful, though the author long thought the male pores would be superficial. Perhaps morphs of more than one species, including one with invaginate male pores, have been referred to *P. robusta*.

Distribution

Burma (at elevations of 2,000 feet to 2,300 meters in the Shan Plateau adjacent to the Chinese province of Yunnan), China, Korea, Japan. Also, Madagascar, Mauritius, in India at Darjiling at 6,000 feet.

The author long has wondered if an amphimictic population might not be found somewhere in China, more especially perhaps, somewhere in a region including provinces of Yunnan and Szechuan.

Regeneration

All naturally induced regenerates that the author recorded were at posterior levels, Each, though small, was caudal. Some even lacked metameric differentiation. Of seventeen metamerically differentiated regenerates, at 65/66-94/95, only one, at 70/71, had as many as four segments. The others had only two or three.

Pheretima rodericensis (Grube, 1879)

North American records

1892 *Perichata dyeri,* Beddard. Proc. Zool. Soc. London, 1892, p. 157. (Jamaica.)

1902 *Pheretima rodericensis,* Michaelsen. Mitt. Mus. Hamburg 19: 9. (Puerto Rico.) Moore, Proc. Philadelphia Acad. Sci. 54; 83. (Bermuda.) Verrill, The Bermuda Islands, New Haven, p. 435. (Comment on activity in Bermuda.)

1937 *Pheretima rodericensis,* Gates. Bull. Mus. Comp. Zool. Harvard 80(8): 365. (Types of synonimized taxa examined. "Diagnosis".)

1942 *Pheretima rodericensis,* Gates. Amer. Midl. Nat. 27(1): 9. (In checklist of North American earthworms.)

1954 *Pheretima rodericensis,* Gates. Bull. Mus. Comp. Zool. Harvard 111 (6): 238. (First mainland U.S. record, Lutz, Hillsborough County, Florida. Dominica, South Africa.)

1958 *Pheretima rodericensis,* Gates. Amer. Mus. Nov. No. 1888, p. 31. (In key to North American species of the genus.)

1963 *Pheretima rodericensis,* Gates. Proc. Biol. Soc. Washington 76: 14. (Greenhouses, Orono and Bar Harbor, Maine.)

1972 *Pheretima rodericensis,* Gates. Burmese earthworms, p. 218. (New state records, Alabama, Georgia. For localities see below.)

Material examined: **ALABAMA.** HOUSTON CO. Dothan, 11 Jul 69, 0-2-6, (TC-63), E. V. Komarek, Sr. **FLORIDA.** ALACHUA CO. Gainesville, Hog-town Creek area, 14 Apr 50, 0-0-11. Northwest corner of University campus, a few hundred yards west, under cut timber on a hammock, 14 Apr 50, 0-0-1, D. E. Beck. Gainesville, 29 Mar 68, 3-1-38 (TC-38), E. V. Komarek, Sr. BROWARD CO. South Andytown, 4 Jul 68, 0-1-0 (TF-408), W. W. Baker & P. E. Jinright. DADE CO. Homestead, under a rubber tree in yard of Mr. Blake, "grunted", 0-0-1. Coral Gables, Fairchild Gardens, 8 Mar 71, 0-0-5 (KO-89), E. V. Komarek, Sr. Junction of Routes 41 and 27W, 3 Jul 68, 0-0-2 (TF-404), W. W. Wilson & P. E. Jinright. INDIAN RIVER CO. Vero Beach, soil under oak trees, Vero Beach Laboratories, 11 Jan 71, 0-0-9, F. Saba. LEVY CO. Otter Lake, backyard right at Otter Creek, 7 Nov 66, 0-10-49, E. V. Komarek, Sr. PASCO CO. Manor Ridge, from a bait store where the worms had been raised from a batch "caught in the woods near Plant City", 12 Oct 71, 0-25-22 (RLC-83), R. L. Crawford & P. E. Jinright. VOLUSIA CO. Daytona Beach, 1 May 67, 0-0-2, 12 Aug 67, 2-3-0. Allandale, 28 Dec 67, 0-0-1, E. V. Komarek, Sr. Daytona Beach, 23 Mar 68, 1-0-7 (TF-523), 10 May 68, 0-0-5 (TF-561A), 12 Jun 68, 0-0-11 (TF-571). W. Wetherill. Allandale, 27 Jun 68, 0-0-2 (TF-573), 0-6-4 (TF-577), W. Wetherill. Port Orange, 1 Jul 68, 0-5-3 (TF-576), 0-6-4 (TF-577). W. Wetherill.

BRITISH GUIANA. Lahaha Street garden, 22 Feb 61, 0-0-3, J. R. Ramsammy. **ENGLAND.** London, Lily House in Royal Botanic Gardens, Kew, 0-0-12, Brian Rees. **JAMAICA.** Folly Point, Port Antonio, Portland Parish, "9.xii.61", A. S. Rand.

Interceptions: **AUSTRALIA.** from 10 pounds of earth in passengers baggage arriving at Seattle, 13 Feb 56, 1-0-1. **INDOCHINA.** from five pounds of earth with *Camellia* sp, in cargo on plane arriving at Los Angeles, 3 Feb 58, 0-0-1. **ITALY.** From soil with *Begonia* plant, in baggage on Andrea Doria arriving at New York, 23 Oct 54, 0-0-1.

External characteristics: 70, 71, 72 (2), 73, 80, 81 (posterior amputees), 83, 84, 85, 86 (after posterior amputation and regeneration or reorganization), 89, 90, 91, 92 (2), 93 (2), 94 (2), 95 (3), 96 (6), 97 (10), 98 (6), 99 (6), 100 (3), Color, reddish, brownish, grayish, even slate. Prostomium, epilobous (all). First dorsal pore, at 12/13 (25). Setae, more widely separated dorsally, sometimes even lacking dorsally between spermathecal pore levels, 28,30,28/ii, 32,30,30/iii, 38,40,38/viii, 38,40,38/ix, 44,42,40/xii, 48,46,42/xx, 51,43,49/xxx, 45,50,48/xl, 48,50,43/l, 47,44,40/lx, 47,47,49/lxx, 42,51,41/lxxx.

Clitellum, annular, brownish to brown, in xiv-xvi, not reaching 13/14 and 16/17 (29), reaching 13/14 but not 16/17 (3+), reaching 16/17 but not 13/14 (5). Female pore, median (33+). Male porophores, circular, more or less distinctly delimited, much smaller than the genital markings.

Genital markings, nearly circular or shortly and transversely elliptical, 4-5 intersetal intervals wide, just median to male pore levels, each with a distinctly demarcated, opaque, marginal band and a central area of greyish translucence, fairly widely separated, at region of 17/18 and 18/19 (those furrows unrecognizable ventrally), possibly originating in xviii but crossing or dislocating the intersegmental furrows. Both pairs present (6), anterior pair often lacking or only one present (3+), posterior markings both present (71+), or only one lacking (1), each of the four lacking (2).

Internal anatomy: Pigment, brownish red, in circular muscle layer, lacking in longitudinal muscle band at mD which is recognizable only behind level of 11/12. Brain, dorso-ventral commissures and subpharyngeal ganglion all left in iii (6 specimens) or in iv (1) by a transverse section exactly along 3/4. Intestinal origin, in xv (33). Intestinal caeca, arising in xxvii, small, reaching forward to 25/26 (7) or slightly into xxvi (1), more or less deeply constricted by the septa through which they pass. Typhlosole, beginning gradually in

the caecal segment, lamelliform, anteriorly with irregularly spaced vertical grooves on each side, through some segments about one mm high, becoming unrecognizable in region of the 57th to 73d segments, leaving 17-31 (most often 27) metameres atyphlosolate (*cf.* Table 7).

Table 7 Typhlosole termination and segment number in *P. rodericensis*.

Segment in which typhlosole ends	Atyphlosolate segments	Total number of segments
57	18	75 pa[1]
58	12	70 pa
60	16	76 pa
60	20	80 pa
63	17	80 pa
64	19	83 pa
64	30	94
67	20	87
68	3	71 pa
68	26	94
68	27	95
68	28	96
68	29	97
69	26	95
69	27	96 (3)[2]
69	28	97
69	31	100
70	27	97 (4)
70	27	97 (4)
70	28	98 (2)
71	24	95
71	25	96
71	27	98 (2)
71	28	99 (2)
71	29	100
72	25	97
72	27	99
73	24	97
73	26	99
73	27	100

[1]pa posterior amputee

[2](2) and (3), etc., number of specimens

Subneural trunk, adherent to parietes, complete, bifurcating well in front of the subesophageal ganglion. Extra-esophageal trunks connected with each other by a short transverse vessel just behind 6/7. Hearts, of ix on left side (24), on the right side (17), of x present (33, filamentous connectives without blood to the dorsal trunk recognized only once), of xi-xiii latero-esophageal but connective to dorsal trunk always without blood. Blood glands, sometimes obvious in v, otherwise not recognized. Lymph glands, unpaired and U-shaped, recognized from xxvii posteriorly.

Prostatic ducts, muscular, 4+ mm long, looped, if in a U-shaped loop the ectal limb thicker, joined below its ental end by the male gonoducts. GM glands, each in a patch of 12-20 discrete lobes, ducts confined to the parietes. Spermathecae, rather small to medium-sized. Diverticulum, from median face of duct at parietes, longer than main axis, with a moniliform seminal chamber markedly constricted into 4-6 consecutive portions. Ovaries, fan-shaped with numerous short egg strings.

Reproduction

Seminal vesicles were soft and filled coelomic cavities of xi-xiii. Prostates filled coelomic cavities of xvii, xviii-xix, xx, or xxi. Brilliant iridescence on male funnels showed sperm had been matured probably profusely. Iridescence of the coagulum in the spermathecal seminal chambers showed copulation had been completed. Reproduction presumably is amphimictic. The reason for suspecting parthenogenesis in the past, was due to the variation in the number of markings (but not their location), their indistinctness, and occasional absence.

Distribution

Australia, Bermuda, Christmas I., Comores, Dominica, Grenada, Jamaica, Madagascar, Mauritius, Martinique, Moheli, New Caledonia, Nossi Be, Puerto Rico, Rodriguez (the type locality), St. Helena, St. Kitts, St. Pierre, Trinidad. All islands! Czechoslovakia, England, France, Germany (Italy ? *cf.* interceptions above), Poland, Switzerland, Russia, U.S. (Maine), in greenhouses only! In Africa; Lagos, Nigeria, Grahamstown, Union of South Africa. In Asia, Foochow, China. In South America, the three Guyanas, Venezuela. In North America, Alabama (1 county), Florida (8 counties), Georgia (1 county). What a puzzle for botany and geography.

The species never has been validly recorded from any part of the *Pheretima* domain as recently delimited (Gates, 1972a: 149). Foochow undoubtedly is within that domain but the *roderícensis* record rests on an interception at Kew, England that long has been regarded as dubious. Leaving Foochow worms out of consideration, there has been no real clue as to where to look for the ancestral home of the species. Now, a single interception (Indochina) provides, perhaps a better clue than the Foochow interception. Which of the present states formerly known collectively as Indo-China really was involved? Even a definite answer may not be of much help, at least until the earthworms of the particular area are much better known than at present.

Regeneration

Tail regenerates; of 4 segments at 58/59, of 8 at 66/67, 4 at 68/69, 2 at 76/77, 3 at 87/88. Several specimens had undergone posterior amputation but whether that had been followed by epigenesis or morphallaxis was not determined.

Abnormality

No. 1. A spiral abnormality involved segments xi-xvi. No. 2. An extra spermatheca was present in vi, on the right side. No. 3. The right posterior seminal vesicle is almost wholly in xiii but is connected through 12/13 to the posterior face of 11/12, by a slender stalk.

Varia

Rudiments of the posterior pair of genital markings of one young adolescent, did seem to be definitely limited to xviii. If a normal origin is wholly within that segment, further growth may either dislocate or even obliterate intersegmental furrow 18/19. If so, then similar growth may well be expected in the presetal half of the segment.

The Lily House worms were in two separate lots, one preserved in alcohol, the other in formalin. Clitellar boundaries were quite distinct on the formalin material, but were indistinct in the alcoholic lot. Pigment, when the material was received, probably shortly after simultaneous preservation, was equally

recognizable in each lot. Pigment was sparse except in the dorsum of the preclitellar region where it extended well out into the prostomium.

Systematics

P. rodericensis, according to Sims & Easton (1972) is in a *diffringens* species group of *Amynthas.* In this author's *diffringens* group, each stalked coelomic gland opens to the exterior through its own, distinctly bounded and discrete genital marking. Such markings are not jammed together even when more numerous as in *P. aspergillum.* Similarly stalked glands of *P. rodericensis* are closely crowded together into four bunches and each bunch opens externally through a single genital marking. The closely crowded pores, presumably minute, may be responsible for the central greyish translucence of the *rodericensis* genital marking.

Pheretima schmardae (Horst, 1885)

North American records

1902 *Pheretima schmardae,* Moore. Proc. Philadelphia Acad. Sci. 54: 63. (Bermudas.)

1937 *Pheretima schmardae,* Gates. Bull. Mus. Comp. Zool. Harvard 80 (8): 368. (Synonymy, "diagnosis".)

1958 *Pheretima schmardae,* Gates. Amer. Mus. Nov. No. 1888, p. 31. (In key to North American species of the genus.)

Material examined. **BERMUDA.** From peat moss with a shipment of frogs, *Eleutherodactylus johnstoni,* from Devonshire Parish, 15 May 64, 0-0-1 (received alive by GEG). D. W. Wingate *per* E. Williams.

Interceptions: **HAWAII.** From earth with 1 plant of *Anthurium* sp., in baggage on SS Hawaiian Builder, arriving at San Pedro, 5 Feb 59, 0-1-0. (Also numerous specimens from six islands of Hawaii, kindly supplied by Dr. Y. Kondo.) **PHILIPPINES.** From earth with 12 unidentified plants in baggage on plane arriving in Hawaii, 26 Jan 60, 6-4-0.

Distribution

China, Chekiang, Hupei and Szechuan Provinces, Hongkong, Macao. Japan.

Bermuda, Barbados, Hawaii, Madagascar, Reunion.

Varia

P. schmardae is not one of the pheretimas known to have colonized commonly and widely. Interceptions during the last quarter century (as above), are not suggestive of frequent transportation. Paucity of records for this hemisphere (Bermuda and Barbados only) may be one of the reasons why Tandy did not mention it. The present Bermuda record is included to show that the species did arrive in this country, recently, and alive, without being intercepted and preserved.

Pheretima spp.

Material examined. Interceptions. **ARGENTINA.** From one fourth pound of earth with *Pilea* plant, in baggage on plane arriving at New York, 13 Jan 50, 1-0-0. **BERMUDA.** From earth with *Lilium* sp., in baggage arriving on S/S Queen of Bermuda, at New York, 13 Jan 50, 2-0-0. From soil sample, arriving in baggage on S/S Queen of Bermuda, at New York, 12 May 58, 1-0-0. From *Amaryllis* bulbs in baggage on S/S Queen of Bermuda, arriving at New York, 23 Jan 54, 2 hatchlings. **COLOMBIA.** From two pounds of earth in passengers baggage arriving by plane at New York, 22 Apr 53, 2-0-0. From earth on roots of orchid plants (*Miltonia*) in passengers baggage, arriving at Hoboken, 23 Sep 53, 2-0-0. From earth arriving by mail at Washington, D.C., 7 Sep 56, 8 hatchlings. **GUATEMALA.** From orchid roots arriving in baggage at Hoboken, 14 Sep 47, 1-0-0. From 40 pounds of earth with *Ceiba pentandra,* in cargo arriving at San Pedro, 3 Aug 51, 1-0-0. **JAMAICA.** From one half pound of earth with croton plant, in baggage on plane, arriving at New York, 5 Mar 60, 1-0-0. **MEXICO.** From earth with 1 cutting (of Musaceae?) from Mexico City, in baggage on auto arriving at Nogales, 19 Mar 63, 2-0-0. From earth with one bromeliad in baggage, arriving at Brownsville, 6 Mar 64, 1-0-0. From bromeliads in cargo on auto arriving at Laredo, Texas, 10 Jul 64, 1-0-0. From earth of one pot in baggage on American auto arriving at El Paso, 14 Jan 65, three fragments of a juvenile. From three bromeliads in baggage on plane arriving at Miami, 17 Aug 65, 3 hatchlings. From 1.5 pounds of earth with oregano, in baggage on car, arriving at Nogales, 9 Jan 66, 1 tail piece. From leaves and stems of 10,000 bromeliads, in cargo on American Truck, arriving at Calexico, 27 Jan 67, 6 fragments. From earth with palm from Guadalajara, Jalisco, in baggage arriving at Nogales, 12 May 49, 1-0-0. From cactus plants arriving at Brownsville, 30 Jun 49, 1-0-0. From earth with geranium plants, arriving by plane at Houston, Texas, 5 Nov 49, 1-0-0. From earth with assorted plants arriving at Gateway Bridge, Brownsville, 23 Mar 50, 5-0-0. from earth with roots of tuberose, in baggage arriving at Brownsville, Texas, 22 Aug 50, 1-0-0. From 1 pound of earth on plant roots, in passengers baggage, arriving at Santa Fe Bridge, 8 Feb 55, 1-0-0. From 82 orchid plants, in baggage on auto, arriving at Brownsville, 17 Aug 58, 9-0-0. From 99 bromeliads and orchids in cargo on plane arriving at Brownsville, 28 Aug 58, 1-0-0. From 259 orchid plants in baggage on auto arriving at Brownsville, 3 Sep 58, 7-0-0. From 613 *Dion spinulosum* in cargo on American truck, arriving at Brownsville, 1 Oct 58, 1-0-0. From bromeliads in cargo on auto arriving at Laredo, 10 Jul 64, 1-0-0. From bromeliads in baggage on auto, arriving at Brownsville, 4 Apr 59, 1-0-0. From 475 orchids and bromeliads in cargo, arriving at Nogales, 28 Jan 60, 2-0-0. From 11 orchid roots in baggage, arriving at Nogales, 3 Sept 60, 1-0-0. From one-half pound of earth with *Dechondra* sp., in baggage on SS Princess Irene, arriving at New Orleans, 4 Apr 61, 1-0-0. **PANAMA.** From earth with coleus in passengers baggage arriving at San Juan, Puerto Rico, 6 Aug 51, 5-0-0. **PARAGUAY.** From 65 plants of *Arachis* sp., in cargo on plane, arriving at Washingotn, 6 Feb 59, 1-0-0. **AZORES.** From earth with two bunches of plants, *Lilium* sp., *Brassica* sp., in baggage on plane, arriving at Boston, 17 Feb 67, 1-0-0. **MADEIRA.** From orchid plants in passengers baggage on plane arriving at Logan airport, 3 Sept 53, 20-0-0. From earth with orchid plants in baggage on plane, arriving at Boston, 18 Aug 67, 1-0-0. From earth with one bunch of orchid plants, in baggage on plane arriving at Boston, 23 Jun 69, 1-0-0. **GERMANY.** From packing on roots of *Cordylina* sp., arriving by plane at San Juan, Puerto Rico, 9 Jul 53, 1-0-0. **GREECE.** From earth with plant in passengers baggage on SS Excalibur, arriving at Boston, 22 Dec 52, 1-0-0. **ITALY.** From earth with citrus trees in passengers baggage, on SS Saturnia, arriving at New York, 9 Mar 52, 7-0-0. From earth in one package of undetermined plants, in baggage on plane, arriving at Boston, 7 Jun 69, 1-0-0. **PORTUGAL.** From earth with plants in baggage, arriving at Boston, 20 Aug 49, 3-0-0. From earth with camelia and canna in passengers baggage, arriving by plane at Logan airport, Boston, 15 Dec 54, 1-0-0. **SOUTH AFRICA.** From earth with orchids arriving by plane at New York, 27 Oct 49, 2-0-0. **INDIA.** From earth with unidentified plant, arriving by plane at New York, 1 Sep 49, 1-0-0. **SAMOA.** From 15 pounds of earth in baggage on plane, arriving at Honolulu, 27 Jul 62, tail pieces. **HAWAII.** From half pound of earth in baggage on SS Hawaiian Builder, arriving at San Pedro, 10 Nov 50, 1-0-0. From 2 pounds of osmunda fibre with

plants of *Anthurium* sp., in passengers baggage on SS Hawaiian Packer, arriving at San Pedro, 25 Dec 54, 1-0-0. From "Ti leaf stem" in mail arriving at Honolulu post office, 25 Feb 55, 2-0-0. From three fern crowns in mail arriving at Hilo, 5 Apr 55, 1-0-0. From half pound of earth in passengers baggage on SS Lurline, arriving at San Pedro, 3 May 55, 1-0-0. **UNKNOWN.** In quarters on plane arriving at Honolulu, 24 Aug 64, 1-0-0. **JAPAN.** From earth in baggage arriving by SS Vassilis at Baltimore, 9 Aug 50, 1-0-0. From 25 pounds of earth with plants in passengers baggage, arriving on USS Cavalier at San Pedro, 23 Apr 54, 1-0-0. From earth with *Prunus* sp., in passengers baggage, arriving by plane at Honolulu, 28 Jun 55, fragments of an intestinal region. From iris in passengers baggage, arriving at Honolulu airport, 12 Jul 55, 1-0-0. From earth in baggage, arriving at Hickam Field Hawaii, 11 Feb 57, 2-0-0. From three cups of earth with a pine in baggage on American SS Vivian, arriving at Seattle, 1 May 61, 1-0-0. From miscellaneous plants in airmail, arriving at Washington, D.C., 16 Jun 61, 1-0-0. From two cartons of various plants in airmail arriving at Washington, D.C., 7 Jul 61, 0-1-0. From 6 bulbs of *Narcissus tarzetta* in baggage on plane, arriving at Hawaii, 3 Nov 62, 1-0-1. From 1 plant, *Azalea bonzai,* in cargo on plane, arriving at San Pedro, 7 Apr 64, 1-0-0. **OKINAWA.** From earth with fern in baggage on plane, arriving in Hawaii, 15 Feb 60, 1-0-0. **PHILIPPINES.** From 3 pounds of earth with unidentified plants in a pot, arriving at New York, 28 Aug 55, 0-0-1. From one plant, *Gesneriad* sp., in cargo on plane arriving at Honolulu, 21 Oct 63, 0-0-1 (macerated and in fragments).

Identification of such juveniles, except to genus, cannot be attempted because our knowledge about the somatic anatomy of most pheretimoids is inadequate for the task.

Of the 132 pheretimoid juveniles intercepted during the last thirty or so years, only 14 came directly to the United States from some part of the *Pheretima* domain, *i.e.,* "The Andaman Islands, the mainland of Asia from the Chindwin-Irrawaddy axis of Burma east through Yunnan and Szechuan provinces of China to include Korea and Japan, thence south to include Java and Sumatra" (Gates, 1972: 149). The other 118, perhaps typically, did not come here directly but from some other outside areas, presumably colonized much earlier.

OCNERODRILIDAE

Ocnerodriles long comprised an undivided subfamily of the Acanthodrilidae or the Megascolecidae. In 1939, the author (J. Thailand Soc. Nat. Hist. Suppl. 11: 72) first indicated distinction from all other megascolecids by five characters, four of which are somatic. As one step toward a much needed revision of the Megascolecidae, it was suggested that "the Ocnerodrilinae, the only group distinguishable from the rest of the family by more than one character, be recognized as a distinct family".

The family now comprises two subfamilies (Gates, 1972a: 267 and 263) distinguished from each other by somatic characters, *e.g.,* presence or absence of calciferous glands in two segments, ix and x. The glandless Malabariinae has endemic species only in India and Burma. One of which has been transported, presumably by man, to the island of Hainan.

OCNERODRILINAE

This taxon is distinguished by the presence of extramural, esophageal glands, paired or unpaired, in one or the other or in both of segments ix and x. The glands have been and still are called calciferous though granules of any sort may never have been seen in any of them. Blood coming into those glands of some species is chemically different from that leaving the glands as is obvious from microtome sections colored with certain stains. The author often has wondered if those organs with a large lumen (as in *Ocnerodrilus* spp.) might possibly function somewhat as does a lung.

Species that lack the *Ocnerodrilus* large lumen have a passageway from the esophagus that, as it passes deeper into the gland, divides and subdivides into increasingly smaller but still distinct canals. Whatever function those interesting glands may have, their structure differs characteristically in each valid ocnerodriline genus. The significance of which has not yet been properly realized. As a result, some genera still are morphologically heterogenous congeries that may be difficult to separate into systematically homogeneous units.

Most ocnerodrile species, unfortunately, are at or near the low limit for megadrile size, which probably has been responsible, at least in part, for the unsatisfactory state of our present knowledge of most ocnerodriles.

Eukerria Michaelsen, 1935

Kerria Beddard, 1892, now known as *Eukerria,* always has been defined as proandric and, since 1900, as quadrithecal (with pores at 7/8-8/9), quadriprostatic (with pores at xix as well as at xvii) and with male pores in xviii. Each one of those just-named genital characters now is known to vary intrageneraically as well as intraspecifically and so can be definitive only when invariably associated with somatic characters not subject to such rapid modification. The type species of the genus is *K. halophila* Beddard, 1892, of which types are lacking. The systematically important calciferous glands of that taxon were said to be "composed of a much folded cellular membrane", a description that applies equally well to the calciferous glands of strongly contracted individuals belonging to species of *Ocnerodrilus,* but which hardly seems in any way applicable to the esophageal glands of *E. kukenthali* and *saltensis.* Only those two species of *Eukerria* really are fairly well known.

Eukerria now appears to be a congeries that may be difficult to resolve.

Eukerria saltensis (Beddard, 1892)

North American records

1954 *Eukerria saltensis,* Gates. Bull. Mus. Comp. Zool. Harvard 111(6): 243. (Dayton, Oregon.)

1972 *Eukerria saltensis,* Gates. Burmese Earthworms, p. 270. (Six new state records, California, Florida, Georgia, Mississippi, North Carolina, Texas. Further data in Gates, 1979.)

1979 *Eukerria saltensis,* Gates. Megadrilogica 3(9): 163. (Distribution in the United States.)

Reproduction

Every dissected American specimen was male sterile. In this country, reproduction presumably always is parthenogenetic. Nevertheless, it should be noted that in Burma where the species also is exotic, reproduction by amphimixis is possible perhaps probably, even usually? In the homeland of the species, an amphimictic population perhaps can be expected.

Distribution

Argentina (Tucuman Province), Brasil (Minas Gerais), Chile (Coquimbo, Quillota, Salta, Valparaiso). Presumably somewhere within the region thus indicated, or if not then at least in some adjacent area, is the source from which man has taken *E. saltensis* to its present distribution:

South Africa (3 Provinces), Burma (3 districts), Australia (2 states), New Caledonia, Easter Is., Juan Fernandez I., U.S.A.; California (1 county), Florida (2), Georgia (7), Mississippi (1), North Carolina (1), Oregon (1), Texas (1).

Nematogenia Eisen, 1900

The generotype of this taxon is *Pygmaeodrilus lacuum* Beddard, 1893. The species was based on worms supposedly from Lagos, Nigeria, but which were secured alive from plants at Kew, England. Our knowledge of the internal structure, limited to the original account, was derived from examination of microtome sections damaged by sand that had not been eliminated from the gut before preservation. Each of the "five or six" types is lost. Even if slides with sections can be found somewhere, they are unlikely to provide much helpful information. The genitalia, of such great systematic importance in those days, enabled Eisen to refer some American worms to the supposedly African species. Known differences in other systems were so slight that only a varietal status for the American individuals seemed warranted.

To this day, the generotype, *N. lacuum*, has not been reported validly from its supposed African home. Meanwhile, the American taxon, recognized as a species, has been recorded from Liberia to Congo. Gross structure of its calciferous glands, without trabeculae or macrosopically recognizable canals (Gates, 1962: 5, Figs. A and B), has been described. Whether it is enough like that of *lacuum*, to allow the two to be in the same genus, remains unknown.

Nematogenia panamaensis Eisen, 1900

North American records

1900 *Ocnerodrilus (Nematogenia) lacuum* var. *panamaensis*, Eisen. Proc. California Acad. Sci. (3), 2: 127. (Type locality, Panama. Types, none.)

1904 *Nematogenia josephina*, Cognetti. Boll. Mus. Torino 19(478):3. (Type locality, San Jose, Costa Rica. Types in the Mus. Zool. Univ. Torino.)

1942 *Nematogenia panamaensis* + *N. josephina*, Gates. Amer. Midl. Nat. 27(1): 98. (In check-list of North American earthworms.)

1957 *Nematogenia panamaensis*, Gates. Bull. Mus. Comp. Zool. Harvard 117(4): 442. (An American instead of the previously accepted African origin, is a possibility. "Precis".)

1962 *Nematogenia panamaensis*, Gates. Rev. Zool. Afr. 65(3-4): 257. (Precis, based on specimens from Congo and the Philippines. Reproduction, "presumably biparental.)

Material examined: Interception. **VENEZUELA.** In earth with anthurium roots arriving by plane at San Juan, Puerto Rico, 11 Apr 49, 0-1-0.

Reproduction

No evidence of any kind was found to warrant a suspicion that reproduction might be other than biparental and so is assumed to be amphimictic.

Distribution

Liberia, Guinea, Nigeria, Cameroons, Fernando Po and Congo, the area in which the species formerly was thought to have arisen. From which it presumably was taken to Ceylon, the Philippines and the American hemisphere: Bahamas, Costa Rica, Panama, Venezuela. The author now suggests that an ancestral, amphimictic population should be sought in Central America and perhaps also northern South America.

Phoenicodrilus Eisen, 1900

More nearly adequate characterization of its calciferous glands enabled a resurrection of this genus (Gates, 1977) from the synonymy in which it had been sunk since 1900. Authors of the following African ocnerodriles, rather unexpectedly, had provided enough information about calciferous glands of their species to allow inclusion in the resurrected genus: *Ocnerodrilus (Ilyogenia) africanus* var. *praetorianus* Stephenson, 1925, *granviki* Michaelsen, 1921, *denti* Stephenson, 1930, and possibly also *luykerleni* Michaelsen 1913, with its variety *thomseni* Michaelsen, 1933. Each of those forms is known only from parthenogenetic morphs and from Africa. Available evidence seems to indicate *luykerleni* is more likely to be specifically distinct from *taste* than any of the other taxa.

Phoenicodrilus taste Eisen, 1895

North American records

1895 *Phoenicodrilus taste*, Eisen. Mem. California Acad. Sci. 2: 64. (Type locality, Sierra el Taste, 4,000 ft., Baja California. Also Pescadero. Types, lost.)

1896 *Phoenicodrilus taste* + *P. tepicensis*, Eisen. *Ibidem*, 5; 172. (Type locality of *tepicensis*, Tepic City, Tepic Territory, Mexico, at 4,000 ft. Types lost.)

1900 *Ocnerodrilus (Ilyogenia) taste* + *O. (I.) tepicensis* + *O. (Enicmodrilus) "santi-xavieri"* Eisen. Proc. California Acad. Sci. 3 (2): 112, 120, 133. (Type locality of *sanxavieri*, San Xavier, Baja California.)

1977 *Phoenicodrilus taste*, Gates. La Fauna Terrestre de L'Ile de Sainte-Helene No. 4: 480. (Description of two specimens from St. Helena and 22 from Mexican localities intercepted by inspectors of the U.S. Bureau of Plant Quarantine. Definition of *Phoenicodrilus*.)

Reproduction

The genus as well as its type species is known as yet only from parthenogenetic morphs. Some Mexican specimens, indicated by a slight iridescence on their male funnels that sperm had been sparsely matured. No evidence has been seen that would indicate sperm had been received in a copulatory act. Perhaps careful search will find an amphimictic population somewhere in Mexico or Central America.

Distribution

Mexico. Baja California and the mainland states of Guerero, Guanajunta, Nayarit and Sonora.

Saint Helena. (Kenya, Namibia, South Africa, Zimbabwe?).

Ocnerodrilus Eisen, 1878

Eighteen species of *Ocnerodrilus* were cited in the previous checklist (Gates, 1942: 97) of North American earthworms. The present list includes only one species though a second species now is in another genus.

Two clitellate individuals, collected by herpetologist A. Loveridge in the South Atlantic island of St. Helena, along with 22 Mexican worms intercepted by inspectors of the U.S. Bureau of Plant Quarantine as they were being brought into this country, enabled the author (Gates, 1977: 480) to resurrect *O. taste,* the generotype of *Phoenicodrilus* from the synonymy of *O. occidentalis* where it had been wrongly placed. At the same time[19] two other "species" of *Ocnerodrilus, santixavieri* Eisen, 1900 and *tepicensis* Eisen, 1886, were transferred to the synonymy of *taste.* Subsequently after a review of the literature, but without opportunity to study any actual material (Gates, 1973: 23) seven species names were transferred to the synonymy of the generotype of *Ocnerodrilus, O. occidentalis* Eisen, 1878. They are; *beddardi* Eisen 1893, *comondui* Eisen, 1900, *guatemalae* Eisen, 1893, *hendriei* Eisen, 1895, *mexicanus* Eisen, 1900, *sonorae* Eisen, 1893, and *calwoodi* Michaelsen, 1898. Eisen's six taxa were known only from more or less modified, parthenogenetic morphs that had been distinguished from each other by "fictitious" or systematically unimportant differences. The types of Michaelsen's *calwoodi,* having matured sperm and copulated, were thought, perhaps without adequate justification, to represent an amphimictic population similar to that from which all known *occidentalis* morphs could have evolved. Yet, the *calwoodi* genitalia cannot be properly characterized (*vide* bottom paragraph Gates, 1973: 23). Types are lacking. Whether Michaelsen's subsequent specimens from Cuba and Colombia are available is unknown.

O. agricola Eisen, 1893, *contractus* Eisen, 1893, *limicola* Eisen, 1893, *rosae*[20] Eisen, 1893 and *tuberculatus* Eisen, 1900, like the classical *occidendentalis,* are not species according to some, because they are known only from anatomically degraded parthenogenetic morphs. None of them was synonyzed in 1973 by the author. Because of some slight, possibly insignificant difference from what was then thought to be the amphimictic norm for *occidentalis.*[21] Each is from, Guatemala but whether any amphimictic population of any *Ocnerodrilus* is present in that country is unknown.

O. sabanae Cognetti, 1905 (of Panama) and *simplex* Cognetti, 1904, (of Costa Rica) cannot be referred to any ocnerodrilin genus, until the structure of its calciferous glands, at present unknown, is adequately described. 1973b: 25). Calciferous-gland structure in *O. sabanae* and *simplex* is unknown, as also of course, the generic status of each of those taxa.

O. occidentalis, of classical oligochaetologists, was not a species but only a collection of A (athecal) morphs. To which (Gates, 1973b: 19) were recently added AR (athecal, anarsenosomphic) and even ARZ (AR, additionally without testes and seminal vesicles) morphs. Eisen's other "species" were never seen again. All of their types, of variously modified, defective morphs, were lost. Each was placed (Gates, 1973b: 22-23) in the synonymy of *O. occidentalis.*

[19]Though typed and mailed in 1968, the contribution was not published until 1977.

[20]Should this taxon not be spelled *rosai? Vide* footnote, p. 24, Gates, 1973b.

[21]Eisen is not known to have designated any specimen of any of his species as a holotype. His own collections were destroyed in the San Francisco earthquake and fire of 1906. Prior to that time specimens of some of his ocnerodriles came into possesion of several European museums. Those received by the British Museum in 1904 are listed in the *Nomenclatura Oligochaetologica* (Reynolds & Cook, 1976) as if cotypes. Which they may be.

The original description of *calwoodi* seems to indicate that the types were normal, at least physiologically. Self-sperm had been matured. Foreign sperm had been received during a copulatory act. Those types were from St. Thomas, W. I. Finding no contra-indicating evidence, this author (Gates, 1923:23) also placed *calwoodi* in the synonymy of *occidentalis,* even though information still is needed about spermathecal and male pores. The *calwoodi* morph also has been reported from Colombia and Cuba. Would northern Colombia and an adjacent portion of Panama be the region in which to search for an amphimictic population of *O. occidentalis?*

OCTOCHAETIDAE

This group of genera now is defined (Gates, 1972a: 275) primarily by somatic rather than genital characters. Yet, "The vast oceanic discontinuities in the distribution almost guarantee that the family is polyphyletic *(ibidem), e.g.,* Australia, New Zealand, a northern part of the Pacific coastal region of the United States, Mexico, Central America, West Indies, central Africa, Madagascar, India, Burma.

Whether excretory systems can provide clues leading to a resolution of the polyphyly, remains undetermined.

All widely transported species are in one genus of unknown origin.

Dichogaster Beddard, 1888

This classical genus of some 200 species in tropical Africa and America, like its African generotype *D. damonis* Beddard 1888, is very much in need of drastic revision. Five species of a *bolaui* group, are fairly well characterized, because of studies made on Asiatic material. Whether they are of African or of American origin, may be difficult to determine.

Dichogaster bolaui Michaelsen, 1891

American records

1896 *Benhamia "bolavi" palmicola + B. rugosa,* Eisen. Mem. California Acad. Sci. 2: 132, 136. (Orchid House, Golden Gate Park, San Francisco, California.)

1942 *Dichogaster bolaui,* Gates. Amer. Midl. Nat. 27(1): 95. (In checklist of North American earthworms.)

1963 *Dichogaster bolaui,* Gates. Proc. Biol. Soc. Washington 76: 11. (Belle Glade, Palm Beach Co. Florida. From a greenhouse.)

Material examined: **TEXAS.** DALLAS CO. Dallas, southwest Oak Cliff at 5500 West Ledbetter Drive, in blackland soil along with *Diplocardia sandersi,* 20 Jan 74, 0-0-1, Ottys Sanders. (The first outdoor record in the U.S.A.) **CLIPPPERTON ISLAND.** August 1958, 0-0-3, Marie H. Sachet. **PHILIPPINES.** Manila, Sampaloc, September 1958, 0-6-23, Magdalene Cantoria. **"SOUTHERN RHODESIA".** Bulawayo, 1 Jan 62, 0-0-1, Dr. D. A. Parker *per* R. W. Sims. ("found by Dr. D. A. Parker, as reported by Miss I. M. Bennie, *in litt.,* to R. W. Sims, in relation to the corpus callosum of a five year old African female who had died the previous day.No cysts were seen in the brain section and no other evidence of parasitic infestation was seen.")

Interceptions: **BRASIL.** From *Anthurium* sp., in baggage arriving at Hoboken, 31 Oct 49, 0-1-12. From *Miltonia* orchid roots, in mail arriving at Hoboken, 11 Jun 54, 1-0-0. **CAPE VERDE ISLAND.** From earth with arum and banana in baggage on Steenstraete, arriving at New York, 27 Mar 59, 0-1-2. **CHINA.** From earth with plant roots in baggage on plane arriving at Honolulu, 10 Jan 50, 0-1-3. **COSTA RICA.** From earth inside hollow cativo log in cargo, arriving at Charleston, 20 Jun 49, 0-1-0. **HAWAII.** From 2 pounds of Osmunda fibre with plants of *Anthurium* sp., in passenger's baggage on S/S Hawaiian Packer, arriving at San Pedro, 25 Dec 54, 0-0-1. **MEXICO.** From orchid plants in baggage, arriving at Brownsville, 11 Jul 50, 0-3-1. From earth with potted plant in passenger's baggage, arriving at Nogales, 22 Jul 54, 0-0-1. From orchids in baggage on auto arriving at Nogales, 18 Sep 57, 0-0-1. From one pound earth in baggage on auto arriving at Nogales, 29 Aug, 1-0-1. From earth with bromeliads in auto, arriving at Nogales, 1 Sep 64, 0-0-1. **NETHERLANDS.** From roots of *Dicentra spectabilis,* in cargo arriving at Hoboken, 23 Nov 49, 0-0-1. **PHILIPPINES.** From 1 pound of earth with unknown plant, in baggage on plane, arriving at Hawaii Port No. 33607, 21 May 62, 0-0-1. **PUERTO RICO.** From soil samples arriving at Isla Grande airport, San Juan, 27 Apr 47, 0-0-1. **VENEZUELA.** From earth with *Gloxinia maculata* in passenger's baggage on SS Rio Dale, arriving at Philadelphia, 9 Jan 50, 0-0-7.

External characteristics: Segments, 83, 85, 89, 91, 92, 93 (4), 94 (2).

Distribution

Australia (1 state), Bolivia, Borneo, Brasil, Burma (25 districts), Cameroons, Ceylon, Colombia, Congo, Dominica, Germany, Guyana, Haiti, India, Jamaica, Java, Madagascar, Malay Peninsula, Mexico, Mozambique, New Caledonia, New Hebrides, Nigeria, Pakistan, Panama, Philippines, South Africa, Sumatra, Trinidad, Uganda, United States (3 states), Cape Verde, Caroline, Christmas, Comoro, Easter, Hawaiian, Loyalty, Marianna, Palau and Solomon Islands.

Regeneration

No. 1. A metamerically unsegmented periproct at 46/47. No. 2 Tail regenerate of four segments at 57/58. Nos. 3-6. Other tail regenerates (of 6 segments) were at levels 33/34-62%63. An anterior amputation at 15/16 had been followed by formation of an imperforate cicatrix.

In the author's Indian laboratory during World War II, posterior substrates, during three weeks, regenerated heads with normal metamerism as follows; (Nos. 7-16) of four segments at 7/8, of five segments at 8/9, of seven segments at 8/9.

Dichogaster saliens (Beddard, 1893)

American records

1900 *Dichogaster crawi,* Eisen. Proc. California Acad. Sci. (Zool.) 2: 228. (Intercepted at San Francisco among roots of plants from Honolulu. Also one specimen from a greenhouse at Del Monte, California.)

1942 *Dichogaster saliens,* Gates. Amer. Midl. Nat. 27(1): 96. (In checklist of North American earthworms)

Material examined: **ZAIRE.** Kinshasa (formerly Leopoldville, Belgian Congo, 1934, 0-0-1. A Tinant. (From a tube labelled, *Gordiodrilus robustus congicus*)

Interceptions: **FLORIDA.** From 25 roots of *Furcraea gigantea,* in air express destined for China, arriving at Washington, D.C., 10 May 60, 0-0-1. **ECUADOR.** From earth with a fern, in baggage on plane arriving at Boston, 10 Sep 64, 0-0-1. **BRASIL.** From anthurium roots, in passenger's baggage on plane arriving at New York, 19 Nov 62, 0-0-1.

External characters: Genital marking, median, across 15/16.

Internal anatomy: The typhlosole ended in the 85th of 111, and the 86th of 119 segments, at first seemingly in the 66th of 76 segments (a posterior amputee). However, more careful inspection revealed a regressed rudiment that extended several segments further.

Reproduction

Probably amphimictic, as indicated by presence of own-sperm on the male funnels and of foreign sperm in the spermathecae.

Distribution

Australia, Burma (4 districts), Ceylon, Christmas Is., Congo, India, Java, Malay Peninsula, Panama, South Africa, Uganda, (United States). There is as yet no outdoor record for the United States.

Several years ago, a skeptical scientist doubted this author's statements as to how little was known about the earthworms of our southern states. Would he be more inclined to believe that in spite of all the recent collecting in Florida, our only Florida record of *D. saliens* is of one clitellate specimen intercepted on its way, out of this country, to China?

Dichogaster sp. I

Material examined: **FLORIDA.** MONROE CO. Big Pine Key, Watson's Hummock, hardwood forest on Indian shell mound, 9 Feb 71, 1-10-2 and a tail piece. S. Peck.

External characteristics: Size, 82-95 by 2-4 mm (not strongly contracted). The anterior end is rather hour-glass shaped, greatest width attained in region of xi (due to presence of strongly muscular gizzards), gradually narrowing until body is thinnest at xv, xvi, or xv-xvi, thickness gradually increasing posteriorly until xx, xxi or even xxx. Segments, 160. 188, 190. Color, white (without pigment). Setae, closely paired, $AB = CD$, AA slightly $> BC$, $DD > BC$. First dorsal pore, at 11/12 (12), ?12/13 (1).

Quadrithecal, pores at *A* and 7/8, 8/9. Female pores, in *AA* and at eq/xiv. Seminal grooves nearly straight, in *AB*, between eq/xvii and eq/xix. Clitellum, saddle-shaped, yellow, lacking ventrally in xvii-xx and seemingly in *AA* elsewhere, in xiii-xx. Genital markings, none.

Internal anatomy: Septa, 11/12-12/13 muscularized, 10/11 and 13/14 less so. Special longitudinal muscle band at mD seemingly interrupted at dorsal pore levels.

Gizzards, two (3). Calciferous glands, in xv-xvii, without any macroscopically recognizable lumen (?) but with many, very fine calcareous granules. Intestinal origin, in xix (?) perhaps with an esophageal valve in xviii. Typhlosole, simply lamelliform, nearly reaching gut floor anteriorly, ending abruptly in the 113th, 130th and 136th segments, leaving 47, 58 and 54 respectively atyphlosolate. Lateral typhlosoles, through about 17 segments of a region around xxv-xlii. The tail fragment probably was broken off from a posterior amputee as the typhlosole height gradually diminishes through six segments, leaving 36 atyphlosolate.

Last hearts, in xii (3). Nephridia, behind the clitellum, discoidal, in a transverse row of 12-24 per segment, the medianmost on each side less discoidal than the others, with the tubular looping in part recognizable. Nephridial funnels were not recognized anywhere.

Holandric, seminal vesicles in xi, xii. Prostates. small, passing straight laterally, ducts without any muscular sheen and shorter than the glands. Penial setae and follicles were not found even on prostatic ducts dissected out from the body wall. Spermathecae, small, under the gut, diverticula obviously bi- or tri-partite or only with slight marginal incisions.

Reproduction

Spermatozoal iridescence on male funnels and in the spermathecae indicates that amphimixis can be expected.

Ingesta

Humus. No soil particles recognized. The species may be a selective feeder.

Parasites

Thirteen cysts, each less than 0.5 mm thick were scattered through the first 42 postprostatic segments on the ventral parietes of an aclitellate worm. Several larger cysts were present n x. In xix-lxxi of a clitellate individual, the cysts were larger though not quite one mm thick.

Varia

Prof. Peck reported that no white-man occupation had been within a mile of the shell mound-midden so that European introduction of the worm to the key seemed to him of lower probability than by early Indian inhabitants.

Systematics

Pending a much needed and drastic revision of the genus *Dichogaster* about all that should be said is: The anatomy of this Big Pine Key species is similar to that of the *bolaui* species group (Gates, 1972a: 277).

Dichogaster sp.

Material examined: **FLORIDA.** BROWARD CO. South Andytown, 4 Jul 68, 0-0-1 (TF-408), W. W. Baker & P. E. Jinright. COLLIER CO. Marco, 2 Jul 68, 0-0-4 (TF-400), W. W. Baker & P. E. Jinright. DADE CO. Homestead, 3 Jul 68, 0-0-1 (TF-406), W. W. Baker & P. E. Jinright. North Homestead, 3 Jul 68, 0-0-6 and 0-0-13 (TF-405), W. W. Baker & P. E. Jinright. GLADES CO. South Lakeport, 4 Jul 68, 0-0-2 (TF-412), W. W. Baker & P. E. Jinright. PALM BEACH CO. South Okeelanta, 4 Jul 68, 0-0-3, W. W. Baker & P.E. Jinright. **GEORGIA.** HARRIS CO. Pine Mountain, Calloway Gardens, 4 Aug 67, 0-1-9, B. & E. V. Komarek, Sr. MURRAY CO. and along Holly Creek east of Chatworth, 30 Apr 67, 0-0-2, W. W. Baker.

BRITISH COLUMBIA. Terrace, Spring Creek, woods near bank of stream, 10 Jun 60, 0-0-2, C. H. Mann. **COSTA RICA.** from rotting stalks of *Diatraea,* Hacienda Ojoa de Agua, Heredia, March 1958, 0-1-2, P. W. Oman.

Interceptions: **BAHAMAS.** from earth with unidentified plant in baggage on M/V Gripsholm, arriving at Philadelphia, 7 Dec 60, 1-1-0. **BERMUDA.** with bulb of *Lilium harrisii* (no earth), on SS Queen of Bermuda, arriving at New York, 29 Jul 49, 0-1-0. **BRASIL.** from earth with gardenia, on SS Loide-Bolivia, arriving at New York, 13 Jul 49, 2-0-0. **BRITISH VIRGINS.** from earth in cargo from Tortola, on sloop Bay Rose arriving at Charlotte Amalie, 3 Nov 53, 3-3-1. **CANAL ZONE.** From *Trichopilia suavis* roots, in mail arriving at Hoboken, 16 Aug 49, 0-0-1. From shakeout of 49 plants (Orchidaceae) in cargo, arriving at San Pedro, 19 Oct 54, 1-0-0. **CHILE.** from earth with 8 cactus and 5 succulent plants, in passenger's baggage, arriving at San Juan, 24 Oct 51, 1-0-0. **COLOMBIA.** from 2 pounds of earth, in passenger's baggage on plane, arriving at New York, 22 Apr 53, 1-0-0. **COSTA RICA.** from earth inside hollow cativo log, in cargo, arriving at Charlestown, 20 Jun 49, 0-1-0. **CUBA.** from 1 pound of earth with 2 coffee plants, in passenger's baggage on plane arriving at New York, 6 Aug 51, 0-1-0. From *Tropaeolum peltrophorum,* in baggage on plane, arriving at New York, 30 Dec 57, 0-4-2. **DOMINICAN REPUBLIC.** From earth in baggage, on plane, arriving at San Juan, 9 Mar 49, 1-0-0. From earth with various plants, in passenger's baggage, arriving at San Juan, 6 Sep 51, 1-0-0. From 2 pounds of miscellaneous plant material in baggage on plane arriving at New York, 19 Mar 61, 1-0-0. **GERMANY.** from earth with heather and moss, in passenger's baggage in plane arriving at Boston, 5 Dec 54, 1-0-0. **HAWAII.** From fern pots in baggage on SS Lurline, arriving at San Francisco, 18 Apr 49, 1-0-0. From roots of *Anthurium* sp., in passenger's baggage on plane arriving at San Pedro, 16 Dec 55, 0-1-0. From earth with roots of *Poinsettia* sp., in stores of USS Pine Island, arriving at San Diego, 8 Jan 60, 1-0-0. **HONG KONG.** from earth of root-ball of 1 plant, in baggage on plane, arriving at Hawaii (37803), 30 Jul 63, 0-0-1. **INDONESIA.** from 1/2 pound of soil in mail from Djakarta, arriving at San Pedro, 22 Jul 63, 0-0-4. **JAMAICA.** from earth with six lily roots, in baggage on plane, arriving at New York, 16 May 60, 2-0-0. **LIBERIA.** from 3 plants, in cargo on plane arriving at New York, 7 Jul 59, 1-0-0. **MEXICO.** From earth with *Caladium* sp., arriving at Nogales, 9 Aug 49, 1-0-0. From earth with potted plants, in baggage arriving at Brownsville, 5 Oct 49, 0-0-1. From seed of *Syngonium* sp., packed in wood shavings, in car arriving at Brownsville, 7 Nov 55, 1-1-0. With *Dieffenbachia* cuttings, in car arriving at Brownsville, 6 Aug 57, 0-0-1. With 100 banana plants, in trunk arriving at Brownsville, 6 Aug 57, 0-0-1. From earth arriving at Brownsville, 0-0-1. From garlic, in baggage on car arriving at Nogales, 8 Jan 59, 1-0-0. From 1 pound of earth with tree, in baggage on auto arriving at Nogales, 10 Nov 60, 0-0-1. From earth with *Bougainvillea* sp., in baggage on plane, arriving at Phoenix, Arizona, 24 Apr 61, 0-0-1. From earth with *Hibiscus* sp., in baggage on plane, arriving at Nogales, 26 Apr 61, 0-0-1. From 1 pound of earth with *Cardia* sp., in baggage on auto, arriving at Nogales, 14 Jun 61, 0-0-2. From earth with 2 plants of *Citrus* sp., in baggage on auto, arriving at Nogales, 18 Jul 61, 0-0-1. From earth with a philodendron, in baggage on auto arriving at Nogales, 5 Mar 62, 9-1-0. From 110 plants, *Musa* sp., from Socorra Terran, S. L. P., in cargo, arriving at Laredo, 29 Jul 63, 0-0-7. From zamia plants from Vera Cruz, in cargo on American truck, arriving at Brownsville, 13 Jan 66, 1-0-0. **NICARAGUA.** from 2 pounds of earth, in cargo on plane, arriving at San Pedro, 18 Oct 55, 1-0-0. **PHILIPPINES.** From shakeout of *Renanthera* sp., on plane, arriving at San Francisco, 3 Jun 49, 0-0-1. From roots of *Grammatophylum speciosum,* in baggage, arriving at Honolulu, 31 Jul 50, 1-0-0. From earth with 2 roots of *Lansium domesticum,* in baggage on plane, arriving at Agana, Guam, 9 Nov 65, 0-0-1. From 1 plant of *Acaradium* sp., in cargo from Manila, arriving by PAAA at Hawaii, 29 Nov 65, 1-0-0 ("worm had burrowed into center of growing point. JF"). **TRINIDAD.** from 12 orchid plants, in baggage on plane, arriving at San Juan, 21 Aug 53, 0-0-1. **VENEZUELA.** from earth with orchid plants, arriving at San Juan, 6 Jul 50, 0-1-1.

Condition of most of the above listed specimens was poor, macerated (too weak or to little alcohol), brittle (after partial

drying, or too strong alcohol), juvenile or aclitellate, warranting nothing more than a genus-identifying dissection. Many specimens almost certainly belonged in a *bolaui* species group (Gates, 1972a: 178), and even to *bolaui*.

Megascolides McCoy, 1898

Six little known American endemics of the Pacific coastal region should not be forgotten. They are *Megascolides americanus* Smith, 1897, *cascadensis* Smith, 1937, *eiseni* Smith, 1937, *macelfreshi* Smith, 1937, *michaelseni* Smith, 1937, *wellsi* Altman, 1936. The first of those species was reported from a single locality in Washington and later from one in Idaho. The others were recorded from Oregon but in each instance from a single locality. The genus is Australasian and at one time contained an Indian endemic still known only from its type locality in Darjiling district.

The six North American endemics, when properly characterized, probably will require a new and definitely North American genus (the eighth).

Trigaster Benham, 1886

This zoogeographically interesting, North American genus comprises seemingly endemic species in Cuba, Mexico, Puerto Rico, St. Thomas and now St. John of the Virgin Islands (American). *Trigaster,* like *Zapotecia* as well as an American section of the classical congeries known as *Eodrilus,* with supposed endemics in Mexico as well as West Indian Islands, provide an interesting challenge to zoogeographers, unless and until transportation from a continental land mass can be demonstrated.

Trigaster intermedia Michaelsen, 1900

1899 *Trigaster lankesteri* (part), Michaelsen, Zool. Jb. Syst. 12: 131.

1900 *Trigaster lankesteri intermedia,* Michaelsen, Arch. Naturg. 66: 235. Das Tierreich, 10; 332.

1942 "*Trigaster intermedia* (or *calwoodi*)", Gates, Amer. Midl. Nat. 27: 94.

1971 *Trigaster intermedia,* Gates, Assoc. Mexican Cave Stud. Bull. 4: 4. (In key to the seven species of the genus.)

Material examined: **VIRGIN ISLANDS.** St. John, Reef Bay, 75' from the shore line and 15' above the sea level, between two flat stones, 27 Jul 72, 0-1-0. R. A. Mendez *per* E. Kirsteur. (The worm arrived in this country alive and was not intercepted.)

External characteristics: Length, 205 mm. Diameter, 5 mm in the gizzard region, 2 mm through most of the intestinal region. Segments, *ca.* 580. Secondary annulation, one deep second furrow in iv, two per segment from v, behind ix secondary and tertiary furrows of about the same appearance. A metameric anomaly involves v-vii. Segment i is about 1 mm long, metameric length gradually increasing to ix, then decreasing gradually through xvi, behind xvii very short. Color, nondescript. Prostomium, prolobous, retracted. Peristomium, finely furrowed both dorsally and ventrally, rugosities reaching all the way to 1/2. Setae, small, recognizable only with difficulty, seemingly not widely paired, *AB* slightly < *CD ca.* = *BC* much < *AA, DD* ca. = 1/2 C. First dorsal pore, at 12/13.

Quadrithecal, pores closely paired (?) in *AA,* Female pores, presetal in *AB*/xiv (?). Seminal furrows, closely paired, but in *AA* which in that region is quite small, in xvii-xix. Clitellum, not yet developed though the epidermix in region of xvi-xxvi, seems more glabrous than in adjacent segments. Genital tumescences, dubious, if at all present rudimentary, paired, in *AB* at 16/17, possibly also in *BB* in a short region behind xix. (Genital apertures were not recognized, sites determined from the dissection.)

Internal anatomy: Septa, 5/6-8/9 obviously muscular, 9/10-13/14 decreasingly strengthened. Pigment, none recognized but the circular muscle layer, in the dorsum, especially from region of xxvi anteriorly had a light brownish translucence that was lacking in the epidermis and the longitudinal muscle layer. The coelom of the last fifteen segments was packed with brown debris none of which had as yet been aggregated into definite brown bodies.

Gizzards, three, in v-vii. Esophagus, widened in x-xiii, moniliform, gorged with blood, without calciferous lamellae. Typhlosole, rudimentary but definitely recognizable. A ventral typhlosole, represented by two, closely paired low, longitudinal ridges from the region of the 60th to the 215th segments. Caeca and supra-intestinal glands lacking.

Dorsal blood vessel (single), ventral trunk, a supra-esophageal vessel and extra-esophageals (median to the hearts), present. Hearts, of ix lateral, slender, of x slender but perhaps latero-esophageal like the larger hearts of xi-xiii.

Nephridia, very poorly preserved, probably numerous, small, in a transverse row at the middle of each side of the body of each postclitellar segment. A large vertical mass, seemingly of fine nephridial tubules was on each side of the gut in iv.

Metandric, tissue masses at supposed sites of the anterior testes were dorsoventrally elongated. Male funnels, small, finely and closely frilled, present only in xi. Seminal vesicles, small, finely acinous, in the lower portion of the coelomic cavity in xii. Prostates, slender, closely coiled, scarcely thicker than their ducts which are less than one mm long and pass straight laterally on the body wall. Male gonoducts, not seen, (within the body wall?).

Spermathecae, small, subesophageal, flat against parietes and just reaching 8/9, 9/10. Coelomic portion of the ducts much shorter than the ampulla. Diverticulum, nearly covered anterior (but dorsally facing) side of the duct, with marginal incisions possibly indicating several seminal chambers.

Parasites

A cyst was associated with the right spermatheca of ix and similar but smaller cysts were scattered on the parietes in the 100th to 200th segments.

Systematics

The three subspecies of *lankesteri* allowed by Michaelsen (1900), *typica, intermedia* and *calwoodi* have no claim to that status. If only one species of the genus is present on St. Thomas, the name of *lankesteri* may have to be retained even though there is little warrant for doing so in Benham's description. The St. John specimen appears to be more like Michaelsen's worms. Supposed differences between *intermedia* and *calwoodi* are quantitative and may be of little, if any, importance.

EUDRILIDAE

Endemic species of this family are present only in tropical and subtropical Africa. The genitalia are highly evolved. Supposedly so much so, in some species, as to allow post-copulation, internal fertilization, which is unknown (and functionally impossible?) in other megadriles.

The above separation (spatial and non-alphabetical) from all other megascolecoid families expresses the author's opinion that the other families are more closely related to each other than any of them is to this African family.

Eudrilus Perrier, 1871

Species of this genus are endemic in tropical West Africa, including Sierra Leone, Liberia, Ivory Coast, Togoland, Nigeria and Cameroons. Somewhere in that area or the near vicinity, the only widely transported eudrilid must have arisen.

Eudrilus eugeniae (Kinberg, 1866)

North American records

1872 *Eudrilus lacazii,* Perrier. Nouv. Arch. Mus. Paris 8: (St. Pierre Miquelon. That record, so far from the tropics, never has been confirmed and seems very unlikely! GEG)

1893 *Eudrilus erudiens,* Ude. Zeit. Wiss. Zool. 57: (Bermuda.)

1899 *Eudrilus eugeniae,* Michaelsen. Mitt. Mus. Hamburg. 16: (St. Thomas, West Indies.)

1900 *Eudrilus eugeniae,* Eisen. Proc. California Acad. Sci. (3), 2)3): 135 ("most common of the large terrestrial earthworms in Panama".)

1902 *Eudrilus eugeniae,* Moore. Proc. Acad. Nat. Sci. Philadelphia 56: (Bermuda.)

1908 *Eudrilus eugeniae,* Michaelsen. Zool. Jb. Suppl. II: (Bahamas, Haiti, St. Thomas.)

1921 *Eudrilus eugeniae,* Michaelsen. Ark. Zool. 13: (Bahamas.)

1934 *Eudrilus eugeniae,* Michaelsen. Mitt. Mus. Hamburg 45: (Cuba.)

1942 *Eudrilus eugeniae,* Gates. Amer. Midl. Nat. 27(1): 98. (North American records.) Bull. Mus. Comp. Zool. Harvard 89 (3): 137. (St. Croix, Virgin Islands. Description.)

1954 *Eudrilus eugeniae,* Gates. Animal Kingdom 57(1): 14. (First record for a mainland state, at Lake Geneva, Florida. Several specimens with two tails, one of which, figured, has a third tail.) Bull. Mus. Comp. Zool. Harvard 111(6): 223. (Puerto Rico, Haiti.)

1963 *Eudrilus eugeniae,* Gates. Proc. Biol. Soc. Washington 76: 15. (Not reported from greenhouses. Mr. Baker, who first raised it for sale as bait, had shipped it to every state, including Hawaii. Has been cultured in various states as well as several Canadian provinces. Yet, in spite of a continuous and wide distribution for fifteen years, the species has not yet been recorded from a natural habitat on the American mainland north of Panama.) Omodeo, IN: Löve & Löve, "North Atlantic Biota and their History", Pergamon Press, N.Y., p. 142. ("The African species . . . dispersed voluntarily, and involuntarily by man, colonizes much of the United States".!)

1977 *Eudrilus eugeniae,* Gates. Megadrilogica 3(4): 70. (A Florida bait dealer, who first cultured the species for sale, estimated that in his beds "one of every 500 worms . . . has an extra tail.")

1979 *Eudrilus eugeniae,* Gates. Megadrilogica 3(8): 138. (Wewahitchka, Gulf County, Florida, 46 specimens along with *E. foetida.* Probably secured from a bait dealer. GEG)

Material examined: **ALABAMA.** MONTGOMERY CO. Montgomery, 10 Jul 69, 1-8-37 (TC-58), purchased), E. V. Komarek, Sr. **FLORIDA.** CLAY CO. Lake Geneva, culture beds of the T. W. Baker Earthworm Farm, 6 Apr 54, and various subsequent dates, hundreds of specimens, including many with extra tails, also numerous cocoons, as well as much information supplied by the proprietor as requested on various occasions. DADE CO. Florida City, 29 Nov 66, 4-16-66 (TC-33), E. V. Komarek, Sr. GULF CO. Wewahitchka, 10 May 69, 1-3-42 (TC-44, purchased), E. V. Komarek, Sr. INDIAN RIVER CO. Vero Beach, soil under oak tree at Vero Beach Laboratories, 11 Jan 71, 3-5-2, F. Saba. LAKE CO. Leesburg, 6 May 66, 0-5-23 (purchased in Thomasville, Georgia, but supposedly from an earthworm bait farm in Florida.) E. V. Komarek, Sr. MONROE CO. Key West, in a cluster on top of ground under a board, 28 Nov 70, 8-17-0 (DBM-1464, Some of those worms listed as aclitellate may have been postsexual. GEG) PINELLAS CO. Palm Harbor, from culture bed of Winsor Robinson, 7 Dec 66, 0-0-10, E. V. Komarek, Sr. SUMTER CO. Dade Battlefield Memorial Park, in and around worm bed in back of superindendent's house, 14 Oct 71, 8-2-5 (RLC-93), R. L. Crawford & P. E. Jinright. **GEORGIA.** BIBB CO. Macon, hardwood creek, 15 Sep 66, 0-1-0 (abandoned bait? GEG), E. V. Komarek, Sr. **TEXAS.** BRAZOS CO. College Station, July 1970, 0-0-11 (from an earthworm farm), R. N. Hanson. BROWN CO. Brownwood, 10 Aug 68, 9-0-1 (TF-444), W. W. Baker & P. E. Jinright. MASON CO. Grit, 10 Aug. 68, 0-0-2 (TF-437), W. W. Baker & P. E. Jinright.

HAITI. Cape Haitien, 4 Mar 34, 0-0-7, Utowana Expedition.

Interceptions: **BRITISH HONDURUS.** From earth with 2 caladium bulbs in baggage on plane arriving at Miami, 15 Jan 69, 15-1-0. From 1,000 orchid plants in plane arriving at Brownsville, Texas, 20 Sep 59, 0-0-2. **CAPE VERDE ISLAND.** From earth with arum and banana in baggage on SS Steenstraete, arriving at New York, 27 Mar 67, 0-1-0. Courtesy of the U.S. Bureau of Plant Quarantine. (During the last thirty years, only 19 specimens of the African worm were intercepted, on three occasions and from two countries.)

External characteristics: Segments, 167 (2 specimens), 170, 172, 173, 174, 177, 180, 186. (Previously recorded maximum number, 211) On each of those clitellate worms, one or more rudimentary furrows, presumably intersegmental (0), are visible, in a short posteroterminal region. Two pairs of nephropores per segment, at first seemed to be present at *B* and *C,* in postclitellar metameres of some poorly preserved Texas worms. The actual nephropores, definitely circular, obvious, at *C,* are just behind the translucent markings.

Clitellar glandularity was lacking (some Texas worms) in a median transversely elliptical, opaque (not translucent) area, without a demarcating furrow, in *AA* and each of xvi-xviii.

Internal anatomy: Pigment, red, is limited to the circular muscle layer dorsally. Strong muscle bands pass from 4/5 and 5/6 to the parietes at 7/8 and 8/9 respectively. Longitudinal gaps in the body wall musculature, four on each side of the body. Setal follicles of each pair are in contact entally, *CD* seemingly a trifle smaller than *AB.*

Supra-intestinal glands, always present, are in eight to thirty segments, the number perhaps increasing as the worm grows (Table 8). But do the anteriormost glands disappear as new glands are added at the hind end of the series? The subneural vascular trunk is adherent to the body wall (rather than to the nerve cord as in the better known lumbricids).

Table 8. Location of supra-intestinal glands in *Eudrilus eugeniae*.

Serial number	Segments with glands	Size of worms in mm		Number of segments in worm
		Length	Diameter	
1	62-73	14	1	84 (+6)[1]
2	63-70	14	1	88 (+4)
3	61-75	16	1	90 (+4)
4	64-73	17	1	90 (+4)
5	52-67	23	1	94 (+6)
6	67-82	21	1	103 (+4)
7	64-81	24	1	113 (+5)
8	73-90	26	1	113 (+4)
9	70-85	37	1.5	104 (+ 12 +?)[2]
10	75-94	37	2	132 (+6)
11	81-105	33	1.5	133 (+4)
12	82-99	40	2	138 (+4)
13	83-104	44	2	142 (+4)
14	82-108	48	2	156 (+6)
15	99-129	97	4.5	184 (+5)

[1]84 metamerically normal segments followed by a growth zone in which rudiments of 6 segments can be recognized. In such a zone, setae are lacking, invisible externally, or, if recognizable, much smaller than in preceding metameres. Intersegmental furrows are complete anteriorly but posteriorly are incomplete dorsally. The anus usually has not yet become completely terminal and still is slightly dorsoterminal.

[2]This worm had a tail regenerate of 12 segments with a large growth zone in which estimation of segment number was inadvisable.

Nephridia, in postclitellar segments, are flattened against the parietes, nearly reaching nerve cord and mD, filling most of the space between gut and body wall, avesiculate (unless a vesicle is slenderer than in most earthworms), cells of the peritoneal investment packed with opaque spheres, not smoothly discoidal (as in some dichogasters) but variously incised marginally. Toward the hind end, metabolites may be lacking in small areas of a nephridial disc, so that a short portion of a nephridial loop is visible. Sometimes, a slenderly and elongately-ocarina-shaped vesicle does seem to be present. When the supposed vesicle rarely is not collapsed, a short cord that may be a duct passes into the parietes in region of *AB*. Nephridia of preclitellar segments are vertically placed on anterior faces of septa in opened specimens. The peritoneal cells lack the metabolites that are present posteriorly.

Reproduction

Probably is amphimictic but that assumption is possible because sperm usually are matured. Also, because of inability to find any of the evidence for parthenogenesis so often available when megadriles are parthenogenetic.

Distribution

E. eugeniae has been said to be pantropical or (Michaelsen, 1900: 402) "uberall den Tropen verschlept". Such characterzations may have to be qualified by some such qualification as, IN THE LOWLANDS, when adequate data as to elevations are available.

The species has been distributed by man, since 1950, into every state of the Union and many of the Canadian provinces. It also has been cultured indoors and/or outdoors in many of those places. Yet no evidence has been found in support of any acquisition of domicile, even in southernmost Florida. Any temperature below 40° F has been thought to be fatal by those who attempted cultures outdoors.

Elsewhere: Anjouan, Bahamas, Bermuda, Brasil, Burma, Cameroons, Cape Verde I., Ceylon, Colombia, Cuba, Fernando Po, French Guiana, Great Comoro, Guyana, Haiti, India, Ivory Coast, Liberia, Madagascar, Martinique, Mayotte, Moheli, New Caledonia, New Zealand (? Never confirmed), Nigeria. Panama, Puerto Rico, St. Croix, St. Helena, St. Pierre Miquelon (this record, never confirmed, is very doubtful,) St. Thoinas, Sierra Leone, Suriname, Trinidad, Upper Guinea, Venezuela.

Life History Notes

Ventral setae of xvii already had been dehisced and apertures of their follicles usually had disappeared before first rudiments of invagination of copulatory chambers appeared as shallow transverse slits. Fan-shaped gonads still were recognizable in some-what larger juveniles, at the usual locations in x-xi and xiii; the latter pair being slightly larger. Gonoducal funnels were represented by discoidal thickenings on the anterior faces of septa opposite the gonads. Rudiments of vaginal apertures and of spermathecae were unrecognized in those juveniles, even though seminal vesicles were fairly well developed.

At the site where ovaries should be located (in one aclitellate) the only structures found were fluid filled sacs containing small bodies that may have been free ova.

Cocoons received by the author in April were mostly with well developed wormlings; some already had hatched and others emerged as their cocoons were examined. Number of hatchlings per cocoon; 1 (4 cocoons), 2 (8), 3 (6), 4 (3), 5 (3), 6 (3), 7 (1), 8 (1). A little of the red pigment already seemed to be present in the hatchlings.

The posterior terminal region of almost every specimen looked like a growth zone. Even the largest, fully clitellate individuals always seem to have a terminal region in which the anus is not yet completely terminal and with the last few segments still not demarcated dorsally, from each other.

Abnormality

(For Nos. 1-2, see Gates, 1942b: 142). No. 3 Male terminalia, lacking. Male gonoducts, thicker than usual, even for a fully mature clitellate worm. Perhaps distended by sperm (?), narrowing to a point terminally in xx on the right side, in xxiii on the left side. On each side without entering the body wall. No. 4. Left side. An extra copulatory chamber in xviii, with an unusually large penis, the chamber in xvii, normal. Right side. The chamber of xvii represented only by a slight parietal invagination without porophores. No. 5. Left side, vaginal aperture in xiv, external male aperture in xvii. Prostate and Y-gland, lacking though Y-gland porophore and the penis are present and of normal conformation. The male gonoduct does not enter the copulatory chamber. Right side, vaginal aperture in xii, male pore in xviii. (Metamerism was normal, at least in the first 25 segments. No. 6. Vaginal apertures in xv, male pores in xviii. Metamerism normal. The unusual conditions of this worm could have arisen in at least two ways; from halving of embryonic blastomeres at some, one level in front of 4/5 or from hypermeric regeneration also at or in front of 4/5. No. 7. An extra vaginal aperture in xv, on the right side.

Constant presence of a growth zone and the correlation of size and segment number does suggest that new segments are formed after hatching. Do the glands move posteriorly as soma size increases? OR, do the anteriormost glands disappear as new glands are added at posterior end of the series?

Parasites

Protozoan parasites of any kind never were seen in any eudrilid, by the author. One nematode female was referred to *Thelastoma*, of which it may be a new species but probably was never described. A series of articles on nematodes secured from the author's earthworms unfortunately was terminated by natural catastrophes and war in what is now Bangladesh. Efforts to stimulate interest in other parasites of earthworms were mostly futile.

Regeneration

Hypermeric head regeneration may have been involved in one specimen but the level of regeneration was not exactly determinable. The longest tail regenerate secured was at 39/40. The anus still was dorsoterminal, indicating that the period of rapid segment production was not yet ended.

Historical Note

Man unwittingly, has been transporting earthworms from one place to another, for more than two millenia. As one result, more than thirty African, Asian, European and South American earthworms now are domiciled in the midland North American states and provinces. Time of arrival here and manner of its subsequent dispersal is exactly known for just one of those species.

Farmers, gardeners, conservatory and greenhouse owners, (on a wholesale scale, the entire greenhouse industry), horticulturalists, orchardists, indeed all sorts of people, interested for a variety of reasons in plants, have been involved, indirectly or directly, in the introduction and transport of live plants. Almost always with their roots in soil. A medium that, in absence of proper precautions, probably most often contained earthworms. And probably most often those worms were of an exotic species. Excepting only one of the exotics, and that from Africa.

The African species, unrecorded from greenhouses, rarely intercepted by inspectors of the U.S. Bureau of Plant Quarantine (see p.), during the last quarter century, owes its present North American distribution *solely* to anglers and angling, *i.e.*, to non-commercial, sport fishing.

The saga of *Eudrilus eugeniae* in North America begins with a can of worms (bait) inadvertently left behind when its out-of-state owners departed from a Florida, angler's camp at Lake Geneva. The immediate source of those African earthworms is, of course, unknown. The nearest and most likely place from which they could have been secured is the Bahamas. From that initial lot of several hundred specimens, the camp owner who had been culturing other megadriles for sale as bait, gradually built a large stock. The new form was found to be an attractive bait to fish, a welcome food to platypuses, woodcock and other animals that were being watched or studied in captivity. Since 1950, in a period of less than thirty years, *E. eugeniae*, under a variety of trade names such as "the African night crawler", has been distributed into every one of the lower 48 states as well as Hawaii, and most of the Canadian provinces. It has been cultured, at least for a time, indoors or outdoors, in a considerable number of states. How many specimens of the "African Red" may have been carelessly discarded at end of a fishing trip would be difficult even to estimate, though numbers may have reached into hundreds of thousands. How many unused specimens may have been carefully planted in some supposedly good habitat near a favorite fishing site, would be even more difficult to guess. Yet, no evidence has been found hitherto (in 1982), of natural colonization, in the mainland states and Canadian provinces.

Extra tails in *Eudrilus eugeniae*

Decades ago, probably in the early twenties, the author read, in some long-forgotten source, that a German had sought, in vain, among forty thousand earthworms for a specimen with an extra tail. If one had been found, the reader noted mentally at the time, the specimen secured with such an effort, presumably should justify careful study to learn, if possible, the cause of the unusual development in a megadrile.

Responsible individuals whose business involved millions of "night crawlers" reported (Gates, 1977: 70) never having seen any two-tailed specimen of *Lumbricus terrestris* Linnaeus, 1758, which is rather common in North America as well as Europe. The author has recorded (Gates, 1978: 78-79) two night crawlers, each of which did have a lateral outgrowth from a posterior portion of the body. Neither of those growths, though basically caudal rather than cephalic, could be called a normal tail.

Three, in a batch of eleven earthworms forwarded by a Florida bait-dealer for identification had an extra tail (Gates, 1954a, b) One of the three, even had a much smaller, though also normal, third tail. The worms were identified as *Eudrilus eugeniae*, an African species not previously recorded from any mainland state of this country. Correspondence with the owner of the business[22] revealed that extra tails were fairly common in his culture beds. Indeed, it was estimated that one in every 500 of the worms that were being raised for sale had an extra tail. Mr. Baker was inclined to suspect that the anomaly was congenital. None of the hatchlings that emerged, in the author's laboratory, from live cocoons supplied by Mr. Baker, had an extra tail or showed any likelihood that such a development was impending. However, it must be admitted that only 26 hatchlings were examined by the author as they emerged from their cocoons or shortly afterward.

A slenderly digitiform, lateral outgrowth from the intestine of a megadrile belonging to a quite different family, as it reached the body wall, seemingly had resulted in a circular, parietal perforation through which the intestinal growth projected very slightly to the exterior of the preserved worm. Caudal regeneration, by the species involved, was impossible in the region of the perforation. Had such regeneration been possible, could a similar intestinal growth, on nearing the body wall, have stimulated development of a tail? Each extra tail of *E. eugeniae* that has been seen or recorded hitherto, had appeared only in culture beds where the species was being raised for sale as bait. Could something of the media, in which the worms were living, especially if taken into the digestive system, be responsible for causing an intestinal outgrowth that could stimulate development around it of an extra tail? Although regeneration had not been studied in the African species, the author had recorded (Gates, 1952b: 143) three of the eighty specimens then examined with tail regenerates. Such regenerates also were common in Mr. Baker's cultures.

Eventually more than a hundred adults of *E. eugeniae*, each with at least one extra tail were secured and preserved for future study. Only a few of the specimens had been dissected when the project was abandoned. Because, the author had learned that a graduate student who presumably was hoping for a thesis, was studying similar material secured from a Chicago dealer. However, nothing from that study seems to have eventuated in print. Some of the author's unpublished data as to; level of bifurcation, size and segment number of the parts involved, as well as location of the supra-intestinal glands is summarized in Table 9.

Often one of the two tails, like each tertiary tail, by its much smaller size and its direction, protruding straight laterally, could be regarded as a secondary growth of relatively recent origin. Larger tails, when of secondary origin, always were directed more

[22]Heartiest thanks are due to Mr. Tracy Baker of Lake Geneva, Florida, for his cooperation during several years. Much material, of recent hatchlings, adolescents, fully clitellate adults, even cocoons, information, *etc.*, was most generously supplied free of any charge.

Table 9. Tail bifurcation in *Eudrilus eugeniae*.

Serial Number	Level of bifurcation	Length in mm			Number of segments		Supra-intestinal glands located segments		Presumed or probable secondary axis
		A	L	R	L	R	L	R	
1	51/52	51	53	46	93	96			
2	52/53	40	37	24	81+	43	65-98	58-77	R
3	53/54	58	67	53	88+	94+	67-104	67-93	R
4	53/54	47	56	58	109	93	92-100	87-99	L
5	55/56	47	40	35	81	92	64-90	63-89	L
6	55/56	43	27	34	64+	66+	60-72	70-94	L
7	56/57	42	39	23	97	38	78-94	73-end	L
8	58/59				79	37+	69-93	65-89	L
9	59/60				77+	84+			L
10	59/60	42	37	26	76	46	69-100	62-90	R
11	59/60	47	29	24	70	42	62-81	73-91	L
12	60/61	51	38	40	78	73			
13	61/62	65	50	50	81+	68+			
14	61/62	60	47	24	95+	39+			R?
15	64/65				81+	80+			L
16	65/66	66	59	55	88	96	81-108	74-100	R
17	66/67				66	73	59-96	59-96	R
18	67/68	44	26	21	62+	54+			
19	67/68	58	22	52	45+	98			L?
20	68/69	53	32	23	60+	26+			R?
21	69/70		38	42	79+	84+	77-91	82-110	L
22	69/70	40	12	21	28	61+	59-?	59-86	R
22	69/70	58	22	30	56+	61+			L
23	72/73	50	34	28	72	74+	70-106	70-98	R
24	73/74	81	58	40	90+	41			L
25	74/75	75	64	30	91	44	79-120	76-end	R
26	74/75	75	64	30	91	44	79-120	76-end	R
27	74/75	61	32	41	65+	71+	71-88	71-106	L
27	75/76	53	8	32	13+	70+			R
28	75/76	57	22	31	54	67	68-96	68-99	L
29	76/77	53	28	22	79	58	71-103	71-83	
30	78/79	68	68	42	103+	77	108-126	88-105	R
31	81/82	55	27	25	58+	56+			
32	86/87	58	20	25	58	54+	78-106	78-115	L

A — Unbranched anterior portion. L — Left bifurcation. R — bifurcation. a — Aclitellate.

[1]The right bifurcation of No. 19, appears to be in line with, and a continuation of the anteriomost portion. But, the left bifurcation is of the same thickness and also with identical pigmentation.

posteriorly and when of similar sizes to the originals, could be very difficult to characterize, from the exterior, as primary or secondary. Color differences, such as distinguish any caudal regenerate, no matter how old, from its substrate, even a second caudal regenerate (from its previously regenerated substrate) are lacking between tails of the same individual. Differences in segment size may be lacking or are too small to measure, especially when tails are much larger and of similar size. Although one or even both tails of an individual sometimes had undergone partial amputation or autotomy, no evidence was found to indicate that regeneration had been involved in the production of any of the tails now under consideration. Yet one or both tails of an extra-tailed individual often had regenerates after partial amputation or autotomy. No evidence was found to indicate that any secondary tail had been amputated or autotomized at or near the level of its origin.[23]

What seemed at first to be the original continuation of the main axis of an extra-tailed worm, was definitely thicker than the other and much longer axis. Primarily because of failure to regenerate after loss of a considerable posterior portion. Perhaps also associated with a greater concentration of ingesta than in the other axis.[24]

Each tail usually ended in a small growth zone with the anus dorsoterminal and with very few segments, 3-5, incomplete dorsally. Unless amputation or antotomy, always at an intersegmental level, had occurred. In which case, the affected portion ended bluntly instead of gently and slowly tapering. One such tail that previously had regenerated five segments (plus how many

[23]From the cicatrix that had been formed after posterior loss of a part of one tail of an extra-tailed individual, two equisized outgrowths, each without metameric differentiation as yet, had been formed. Each had its own opening into the substrate gut. If each had continued to grow about equally, they almost certainly would be recognized by color differences from the substrate as products of regeneration.

Various two or three-tailed posterior fragments that had been broken off from their original cephalic portions have been seen. Never seen was a rupture or autotomy at any level of bifurcation.

[24]Dash & Patra's figure (1978: 150) of a two-tailed example of an Indian species, *Lampita mauritii* Kinberg, 1867, seems to have had a secondary outgrowth of lesser thickness but perhaps of about the same length as the supposedly posterior portion of the main axis. The latter probably did not have a normally tapering posterior end, but may have undergone amputation, autotomy, or even some deformation.

others?) and then had undergone a second amputation or autotomy, at preservation still was unregenerate.

Abnormality in metamerism was recorded for each of the three regions of 16 individuals in a series of 32 with extra tails. Twelve of the 32 had such abnormalities in one or two of the three regions; primary and secondary tail, unbifurcated cephalic portion. Only for four of the same series were such abnormalities not recorded either because they were lacking or were unrecognized. The total extent of anomalous metamerism was not determined for any extra-tailed worm but certainly did seem to be much greater than that of almost any single-tailed *eugeniae* that was studied.

Internally, more differences were recorded between tails of an individual. A gut always was present in each tail of an individual but was slender in one tail of at least 15 individuals in the 32 series. Usually the slender gut was empty but whether food could have passed into the empty branch was not determined. Ingesta was present in five of the slender guts, regardless of the considerable differences in gut size. The gut lumen, in each of two tails without ingesta, was partially or completely filled with a translucent to transparent coagulum. The tails with slender guts, regardless of content, probably were secondary in origin though that could not always have been anticipated from external appearance.

A dorsal blood vessel always was present in each dissected tail. That of a secondary axis usually opened directly into the corresponding vessel of the original axis. In two secondary tails, the trunks did not join those of the main axis directly. Blood from the secondary axis of one had to pass though a small plexus just before entering the trunk of the main axis. Several small, short branches conveyed the blood between the two trunks of the other specimen.

Doubling of the dorsal blood vessel was unreported hitherto in the African species, even in otherwise abnormal but unbranched individuals that were dissected. The doubling never was completely continuous, being irregularly interrupted and was restricted to a posterior portion of a tail. Sometimes the doubling was lacking through several consecutive septa or was reduced to a short series of midsegmental perforations. Such anomalies were not recorded from the unbranched anterior portion of each original axis, which often may not have been dissected. (During embryonic development, the anomaly appears because of the failure of paired anlage to fuse above the gut at the median plane.) Other deviation from normal structure in the vascular system was not recognized. Each secondary tail also had a nerve cord that branched off from the cord of the original axis at the level of bifurcation.

A nematode once was found posteriorly in the coelomic cavities of one tail. Protozoa and other parasites were not seen in any of the bifurcated individuals. No evidence was recognized that might justify a suspicion that parasites had been involved in the initiation of secondary tail growth. Large "brown bodies" occasionally were numerous in one or both branches, especially in the posterior segments where similar bodies sometimes were white. A nephridium, in either axis, occasionally showed presence of similar brown material.

One, two-tailed individual could void its ingesta in three ways! Two, as usual, *via* a dorsoterminal anus of each, nearly equisized and long bifurcation, with each gut containing ingesta. The third, through a circular aperture between the bifurcations at their junction where gut and body wall were healed together around an opening into the intestine of the unbranched anterior portion of the worm.

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